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PROPOSAL FOR 1980 FIELDWORK PROGRAM ON THE HAMILTON - SCOURGE PROJECT BY THE INSTITUTE OF NAUTICAL ARCHAEOLOGY

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Proposal for 1980 fieldwork program on the Hamilton-Scourge project by the Institute of Nautical Archaeology

UNDERWATER SPECIALISTS
"ARCTIC EXPERTS"
"CALGARY, ALTA."
DIVERS AND SALVORS

INSTITUTE OF NAUTICAL ARCHAEOLOGY

George F. Bass, *President*
Michael L. Katzev, *Vice President*

P.O. Drawer AU
College Station, Texas 77840
(713) 779-4101

January 12, 1980

W. Jackson
Underwater Specialists
533 - 11th Avenue South West
Calgary, Alberta
T2R 0C9

Dear Mr. Jackson:

Please find enclosed the requested material concerning the Hamilton-Scourge proposal.

For your information, I have included a personal curriculum vitae as well as curriculum vitaes for J. Richard Steffy and Dr. D.L. Hamilton, both of whom are with the Institute and both of whom have agreed to be available as stand-by consultants during the project work.

As you know, I have completed all requirements here at Texas A&M University, for my Master's in Nautical Archaeology, with the exception of my thesis, which should be completed by May of this year. I will be leaving the Institute, at least temporarily, in June, in order to begin a Doctoral program in Ontario. I will, therefore, be available for field work this summer and any necessary follow-up work after the completion of the report. This should be the case through at least the first half of 1981.

I hope you will find the accompanying material satisfactory. Please feel free to contact me at any time with any questions you may have.

I look forward to hearing from you.

Yours Truly,

Kenneth A. Cassavoy
Administrative Assistant

TO: W. Jackson
Underwater Specialists

FROM: K. Cassavoy
Institute of Nautical Archaeology

RE: Hamilton-Scourge Project

DATE: January, 1980

INTRODUCTORY NOTE

The following report provides a very brief planning and implementation outline for a suggested approach to the shipwreck survey proposed by the Hamilton-Scourge Steering Committee in their letter to you of September 11, 1979.

As requested, this report has been kept extremely brief and essentially presents only a concise summary of the major points covered in our recent conversations. Due to the severe time limitations related to the preparation of this report, suggestions made have been put forward without the benefit of personal communication with the principals involved in the initial phases of the work on the project. As a result, some assumptions which have been made for the purposes of discussion, concerning the ships and other aspects of the project, may not accurately reflect already established details of the vessels or of previous work. However, this factor should not seriously affect the general application of the points covered.

This report has been prepared based on the designated sole use of remote control vehicles in all all aspects of the survey.

GENERAL AIMS AND OBJECTIVES

Although the ultimate planned recovery of the vessels, thought to be the Hamilton and the Scourge, is clearly an involved interdisciplinary, scientific undertaking and much more than just an archaeological problem, it seems advisable to approach all phases of the work from an archaeological perspective. In terms of the

1980 field work this simply means that the planned survey should not be undertaken as an isolated photographic phase, but rather as an integral part of a continuing archaeological investigation. All work designed to meet the stated immediate objectives of the steering committee proposal should be carried out using methods which will also develop the maximum possible information related to the broader, long-range goals of the project. This approach calls for an awareness of all the potential information which can be gained during the survey work and an understanding of how this information can be obtained and used. For example, during the course of the general survey work, close attention should be given to the obtaining of, among other things: very precise information on all major ships' dimensions; not only important general construction points but also specific minor construction details of the vessels; detailed information on the provenience and calibre of all shipboard ordnance; the dimensions and details of the remains of the masts and rigging; and full and specific documentation of all visible ships' gear, personal effects, and other artifactual material.

The proposed survey should not simply supply a photographic record of the current state of the wrecks and their environments, but should, to the greatest degree possible, provide:

- Information which is, in itself, historically and archaeologically important.
- Information which will help date the surveyed vessels to the period in question.
- Information which will help provide identification details, both positive and negative, related specifically to the Hamilton and the Scourge.
- Information on the vessels, on the overburden and sediment, and on the general surroundings, which will be helpful in planning the recovery phases of the project.

- A complete bank of illustrative and other information which will allow the preparation of a fully-interpreted and detailed archaeological report which will, in turn, provide a solid basis and direction for future work on the sites.

SURVEY PLANNING AND IMPLEMENTATION

The following series of nine steps cover briefly all the major aspects of the suggested approach to the planning and implementation of the 1980 Hamilton-Scourge Project survey.

1. Consultation and Familiarization

Initially, meetings should be arranged with all steering committee members and the principals from all agencies involved in every aspect of the work to date. Those undertaking the work should familiarize themselves with all information already established concerning the ships and the sites and carry out a detailed study of all existing written and photographic material, including the original videotape recordings of the vessels. During this consultation and familiarization process the aim should be to fully understand the immediate expectations of all those involved in the work to date and to gain a clear perspective on the long-range goals and objectives of the committee.

2. Preliminary Research

In order to effectively survey the vessels and meet the research objectives, it will be necessary for those carrying out the work to become totally familiar with the vessels, prior to beginning any field activities. With this in mind, an extensive research program should be undertaken which would include:

i. A search for original plans, drawings or other pictorial depictions of the Hamilton and the Scourge.

ii. A search for contemporary plans, drawings and depictions of vessels suggested to be of the same general dimensions and of the same general type as the Hamilton and the Scourge.

iii. A search of all pertinent contemporary documents which may provide helpful details of construction, rigging, ordnance, etc., specifically in terms of the Hamilton and the Scourge.

iv. A review of all pertinent major text sources related to vessels of the period.

v. The construction of scale models replicating the environment, the positioning, and the current state of the vessels. These models to be used as illustrative aids during both the preliminary planning and the field work period.

vi. The drawing of preliminary site plans including theoretical grid systems, to assist in the detailed planning of the step-by-step accomplishment of all objectives.

These drawings to include a "central" site plan (the ship and immediate surroundings) and an "overall" site plan (150 square metres around each vessel) with appropriate theoretical grid sizing for each plan.

vii. A review of the pertinent literature related to the effects of the prolonged submersion of wood and other organic and inorganic matter, in water - specifically in terms of the environment in which the vessels are known to be located.

viii. A full review of the literature related to the survey phases of comparable underwater projects in all scientific disciplines.

Some of these activities, especially in terms of the search for ships' plans, may already have been carried out but, if these have been unproductive, further attempts in this direction would seem to be appropriate.

On this point, preliminary discussions in Washington, D.C., with Mr. John Reilly, Historian, U.S. Naval Memorial Museum and Dr. Phillip Lundeburg and Mr. Howard Hoffman of the Smithsonian

Institution, indicate that plans for the Hamilton and/or the Scourge may not exist - certainly they are not readily available. There is some indication that known documents in the U.S. National Archives, especially the "Captains' Letters" of the Great Lakes Squadron, might provide some useful information. As well, the Peabody Museum in Salem, Massachusetts and the Naval Historical Branch of the Ministry of Defence in London, England, may also hold documents containing pertinent information.

Again, even if these sources have already been explored, as a minimum, they should be intensively re-examined with the aim of locating all possible new information.

3. Survey - Central Site

Using a fixed positioning point, near the central point of the vessel's hull at deck level, the following television and photographic surveys should be undertaken:

i. Preliminary general television survey of the ship's hull, masts and rigging, to provide initial orientation and familiarization.

ii. Television survey of ship's hull following a designated path corresponding to the established theoretical grid pattern (see Illustration 2). This survey should be used as a primary source of dimension information.

iii. Detailed 35mm photographic survey of the hull - starboard, port, bow, stern, and deck - based on a three square foot individual frame coverage, with a maximum 50% overlap. 450 to 500 prints would be required for each hull series. Concurrent television recording of all areas photographed.

iv. Photographic coverage of masts and rigging as required - 150 to 200 prints for each vessel. Concurrent television recording of all areas photographed.

v. Medium close-up and close-up photographs of all structural details and artifactual materials of special interest -

v. (cont'd) 300 to 350 photos for each vessel. Concurrent television recording of all details photographed.

Note: The use of a semi-rigid reference frame is not recommended on these sites since such a grid is essentially an excavation tool and no excavation is to be undertaken. Experience has shown that the accurate and stable placement and subsequent removal of an acceptable and practical grid system is a very time-consuming undertaking. Given the nature of the project, a fixed grid system is not likely to provide any meaningful improvement in the accuracy of the information obtained but would substantially increase the time parameters for the work.

As indicated above, a theoretical archaeological grid system will be developed during the early planning stages and will ultimately provide the key to control of all work on the sites. Through the use of these grid systems in both the planning and operating/tracking phases, provenience well within the required minimum (1 metre) should be produced (based on established equipment capability, under the known site conditions).

vi. Specific photographic coverage of all areas of the hull at the point of entry into the bottom sediment - 60 prints for each hull. Concurrent television recording of all areas photographed.

4. Survey - Overall Site

Using the fixed positioning point established for the Central Site survey, the following television and photographic activities should be undertaken:

i. Television survey of the full extent of the overall site following a planned track based on the established theoretical grid system. [See Illustration 1]

ii. Photographic coverage, concurrent with (i) above, of any areas or materials of special interest - based on a three square foot individual frame coverage with overlapping

ii. (cont'd) as required. 200 prints estimated for each site.

iii. Medium close-up and close-up photographs of smaller items or features identified as being of special interest. 100 prints estimated for each site.

5. Recovery of Material

It is recommended that the recovery of any material from the sites be carried out using a specially constructed "soft-grip" adaptor on the remote control manipulator. Such recovery should be kept at an absolute minimum. The general aim of all work during the survey should be to leave the sites essentially undisturbed.

The required recovery of loose timbers should be strictly limited to the minimum essential for the necessary analysis and study.

The recovery of artifactual material should not be undertaken unless such recovery provides a clearly demonstrated probability of obtaining important identification information. Any recovery of material should be carried out after completion of all photographic work.

6. Hull Core Samples

The wood hull core samples should be obtained through the use of a special coring adaptor on the remote control manipulator.

It is recommended that hull cores be taken at a point just above the sediment line and again at a point 20 to 30 centimetres below the sediment line, from a small hull section cleared of overburden for this purpose. The overburden could be cleared for this operation using a small water-jet operated from the remote control vehicle.

Hull core samples should be taken after the completion of all survey photographic work.

7. Bottom Samples

The required soil strength measurements, at the various

locations and sediment depths should be obtained using standard bottom coring devices and related measurement techniques which can be employed at the surface. The required torque calculations can be accurately obtained in the sample cores through the use of a "miniature" shear vane mechanism. Alternatively, a "box" core device can be used for the bottom samples which would allow the surface use of standard hand-operated or mechanical shear vanes. The soil strength measurements should be taken as close as possible to the point of contact between the hull and the bottom sediment.

It is recommended that the all bottom sampling be carried out after the completion of all survey photographic work.

8. Follow-up Research

Follow-up research should be undertaken, as required, based on information developed during the field work. This would include research of newly-documented structural features and artifactual material. The focus in this phase, based on new information, would probably centre on general research of dated parallels in terms of both ship construction and documented artifacts. Specific research of these aspects would emphasize points with some apparent application to the *Hamilton* and/or *Scourge*.

9. Project Report

Within four months of the completion of the field work, a project report should be prepared which would include the following:

Illustrations

i. A separate plan of each "overall" site, indicating the location of all artifactual material associated with each wreck.

ii. A separate plan of each "central" site, documenting the location of major artifactual material on each wreck and material in close association.

iii. Separate plans of each vessel's hull - from a deck view and from a sheer view.

iv. To the extent possible, separate plans of each vessel's masts and rigging and suggested sail plan.

v. Photographs and detailed drawings of important structural features, major artifactual items, and other material of special interest.

vi. Depending on photographic conditions on the site during the survey, possibly a photo-mosaic of at least substantial sections of the vessels.

Text

Fully foot-noted, incorporating the above illustrations, and including the following sections as a minimum:

i. Research and Historical Background.

ii. Methodology.

iii. Separate discussion of each vessel in terms of:

  a. Hull construction details.
  b. Masts, rigging and sails.
  c. Ship's gear.
  d. Ordnance.
  e. Artifacts and Personal Effects.

iv. Conclusions and Recommendations:

  a. Discussion of vessel identification both general and specific.
  b. Recommendations related to further research requirements with definition of any major research problems
  c. Recommendations related to further preliminary field work.
  d. Long-range considerations in terms of the planned raising of the vessels.
  e. Other points as determined during field work.

v. Catalogue - To include: details of provenience; dimensions; description; photographs; drawings; condition when recovered; and conservation treatment undertaken - for any items recovered during the field work.

vi. Bibliography - To include full documentation of all text and personal communication sources used in all phases of the work and in the report preparation.

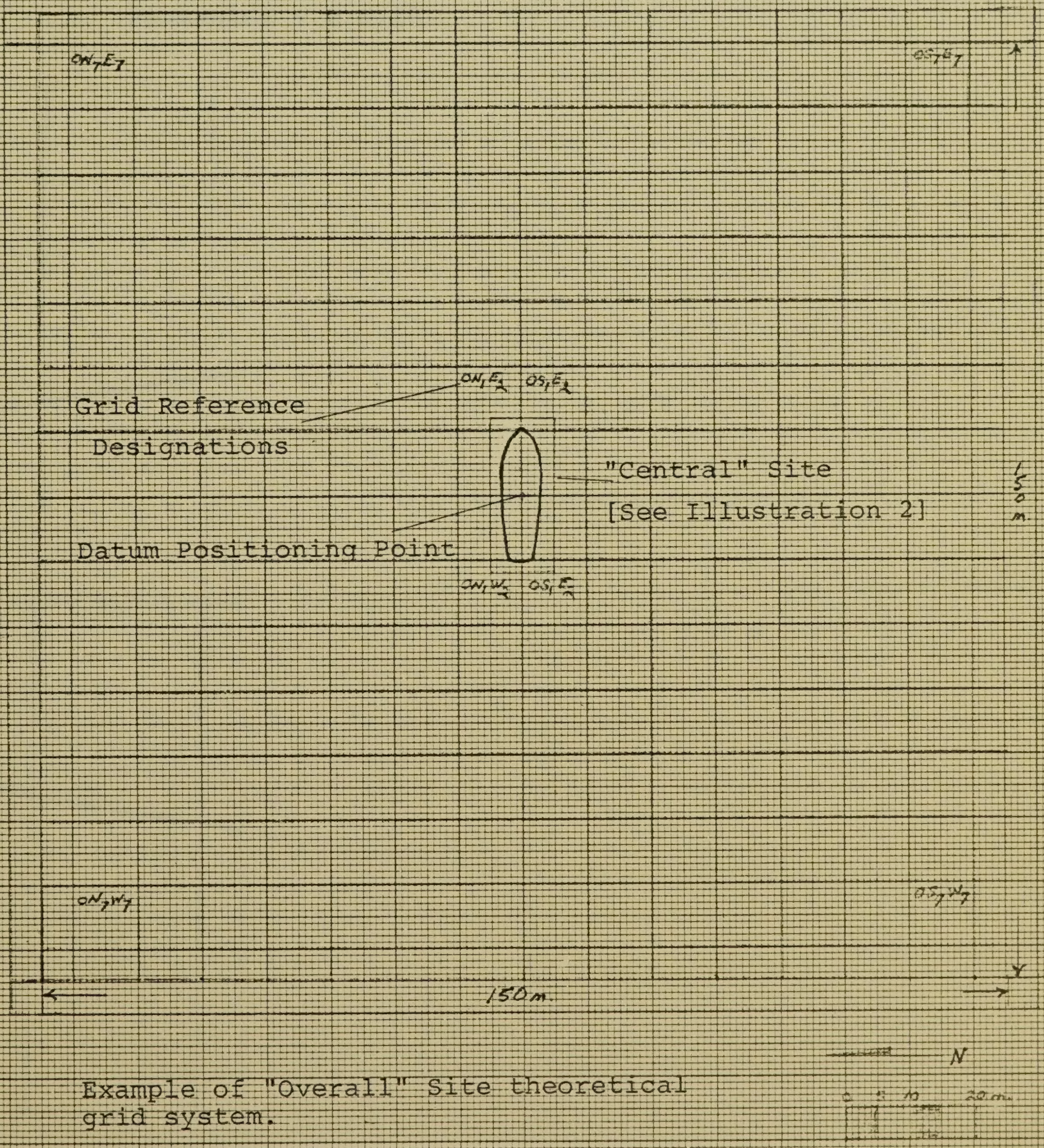
Note: The preparation of the project report may be the single most important aspect of the survey process. With this in mind, the final form of the report should remain somewhat flexible until the completion of all field work but, as a minimum, it should include all of the material mentioned above.

Videotape Documentary

A short, edited documentary videotape, with narration, covering the underwater aspects of the 1980 field work could be prepared at the request of the Hamilton-Scourge Steering Committee. This videotape could serve as an effective visual display tool and a concise supplement to the written report. If arranged in advance, an expanded version could be prepared which would include all surface aspects of the work and a step-by-step documentation of all phases of the project activities.

Kenneth A. Cassavoy
January, 1980

Illustration 1


ON7E7
OS7E7
ON1E½
OS1E½
ON1W½
OS1E½
ON7W7
OS7W7
150 m.
150 m.
N
0
5
10
20 m.

Grid Reference Designations

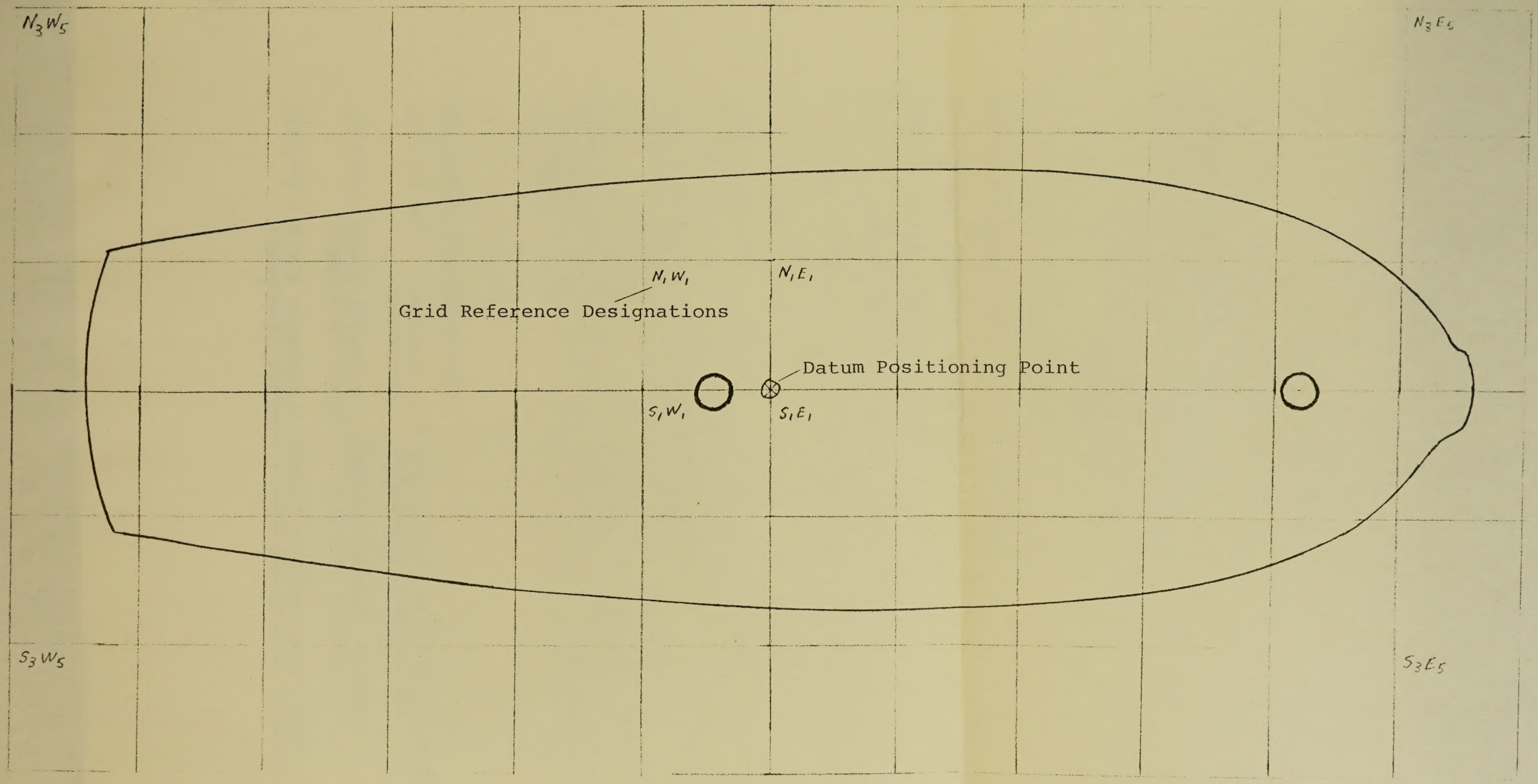
"Central" Site [See Illustration 2]

Datum Positioning Point

Example of "Overall" Site theoretical grid system.

METRIC

Illustration 2


N_3W_5
N_3E_5
N_1W_1
N_1E_1
Grid Reference Designations
Datum Positioning Point
S_1W_1
S_1E_1
S_3W_5
S_3E_5
0
1
2 m.
N

Example of "Central" Site theoretical grid system.

[Hull shape based on Tecumseh - 1815 armed schooner,
Length 70' 6", Beam (Extreme) 24' 5"]

CURRICULUM VITAE

Kenneth A. Cassavoy

Personal Information

Address: Temporary - 1612 Dominik Drive
College Station, Texas 77840

Permanent - R.R.#3
Orillia, Ontario
L3V 6H3

Phone: Texas - 713/693-6546

Social Insurance Number: 413 134 446

Birthplace: Toronto, Ontario

Date of Birth: January 7, 1939

Marital Status: Married Patricia Gail O'Brien, Oct. 16, 1960

Children: Edward H., 17 / Elisabeth D.,15 / Christopher K.,13

Education

Trent University, Peterborough, Ontario
Bachelor of Arts Degree (Anthropology) - 1976

Texas A&M University, College Station, Texas
Master of Arts Candidate (Anthropology - Nautical Archaeology)
[All degree requirements completed at this time with the exception of thesis - scheduled to be completed in May of 1980]

Pertinent Work Experience

1975 to 1977 - Lecturer and Laboratory Instructor - Trent University - Underwater Archaeology.

1973/74 - Field Director - Atherley Narrows Fishweir Underwater Project - Orillia, Ontario.

1974/75 - Field Director - Penetanguishene Naval Slip Underwater Project - Penetanguishene, Ontario.

CURRICULUM VITAE

Kenneth J. Cassavoy

Personal Information

Address: Temporary - 1522 Norfolk Drive
College Station, Texas 77840

Permanent - R.R.#3
Orillia, Ontario
L3V 6H3

Phone: Texas - 713/693-6915

Social Insurance Number: 423 184 216

Birthplace: Toronto, Ontario

Date of Birth: January 7, 1939

Marital Status: Married Patricia Gail O'Brien, Oct. 14, 1962

Children: Edward K., 17 / Elizabeth L., 15 / Christopher S., 13

Education

Trent University, Peter
Bachelor of Arts Degre

Texas A&M University,
Master of Arts Candidat chaeology)
(All Degree requirements the
completion of thesis - a May
of 1980)

Relevant Work Experience

1975 to 1977 - Lecturer a nt
University -

1973/74 - Field Director - Pinnacle
Underwater Project , Ontario.

1974/75 - Field Director - Penetanguishene Naval Slip
Underwater Project - Penetanguishene, Ontario.

1976/77 - Field Director - Hope Island Shipwreck Underwater Project - Georgian Bay, Ontario.

1977/78 - Project Supervisor and Field Director - Charleston Lake Portage Site Underwater Project - Charleston Lake, Ontario.

1978/79 - Research Assistant to Dr. George F. Bass, Director of the Nautical Archaeology program at Texas A&M University, and President of the Institute of Nautical Archaeololgy.

1979 - Team member and Research Assistant to Dr. Bass during June and July work on an 11th century Islamic shipwreck and a Hellenistic shipwreck at Serçe Liman, Turkey.

1979/80 - Administrative Assistant to Dr. Bass at the Institute of Nautical Archaeology. Responsible for day-to-day Institute operations and related archaeological matters.

Reports/Papers/Publications

1974 - "A Preliminary Investigation at the Atherley Narrows Fishweir" - Trent University Research Committee Report.

1977 - "Further Investigations at the Atherley Narrows Fishweir". - Trent University Research Committee Report.

1977 - "The Archaeological Investigation of the Naval Slip Site" (co-author) - Huronia Historical Parks Publication.

1977 - "The Hope Island Wreck: 1977 Monitor and Survey" - Ontario Heritage Foundation Report.

1978 - "A Preliminary Investigation of the Atherley Narrows Fishweir", in American Antiquity, Vol. 43, No. 4, 697 - 709.

1978 - "The Atherley Narrows Fishweir" - Paper presented at the 1978 meeting of the Society for Historical Archaeology/Conference on Underwater Archaeology.

1978 - "The Charleston Lake Portage Site" - Paper presented at the 1979 meeting of the SHA/CUA

1979 - "The Hope Island Wreck Site" - Paper presented at the 1979 meeting of the SHA/CUA

1979 - "Initial Report on the Charleston Lake Portage Site" - Ontario Heritage Foundation Report.

1980 - "The 1978 and 1979 Field Seasons at Serçe Liman, Turkey" - Paper presented at the 1980 meeting of the Archaeological Institute of America.

Member of:- Canadian Archaeological Association
- Society for Historical Archaeology/Conference on Underwater Archaeology
- Archaeological Institute of America

CURRICULUM VITAE

Donny Leon Hamilton

Personal Data

ADDRESS: 3906 Hilltop Drive
Bryan, Texas 77801

PHONE: 713/846-2042

SOC. SEC. NO.: 449-70-7728

DATE OF BIRTH: October 23, 1942

BIRTHPLACE: Levelland, Texas

MARITAL STATUS: Married Betsy Lillian Preston, November 6, 1962

CHILDREN: One daughter, Amy Elizabeth Hamilton, born March 7, 1964. One son, John Preston Hamilton, born December 17, 1974.

Education

Texas Tech University
Lubbock, Texas 79409
Bachelor of Arts Degree conferred May 1967
Major, Anthropology, minor, History

The University of Arizona
Tucson, Arizona 85721
Completed 24 graduate semester hours in Anthropology, 1967-1968

The University of Texas at Austin
Austin, Texas 78712
Doctor of Philosophy Degree in Anthropology conferred May 1975
Dissertation entitled "Conservation of Metal Objects from Underwater Sites: A Study in Methods"

Society of Professional Archaeologists Certifications

A member of the Society of Professional Archaeologists with professional emphases certification in 1) Field Research, 2) Collections Research, 3) Archaeological Administration and 4) Museology (artifact preservation).

Positions

September 1978 to present

Assistant Professor, Department of Sociology and Anthropology, Texas A&M University

Duties: Teach courses in archaeology and conservation of archaeological materials. Direct operations of the Conservation Research Laboratory.

September 1972 to August 1978

Conservator (Research Scientist Associate IV) of The Antiquities Conservation Facility of the Texas Archaeological Research Laboratory, The University of Texas at Austin, Balcones Research Center, 10,100 Burnet Road, Austin, Texas, 78758.

Duties: Direct day to day operation and research program of the conservation facility. Supervise laboratory personnel in treating the materials recovered under the marine archaeology program of the Texas Antiquities Committee and various state agencies conducting archaeological research in the State. Teach courses on antiquities conservation in the Anthropology Department, The University of Texas at Austin.

October 1971 to August 1972

Research Associate at The Antiquities Conservation Facility of the Texas Archaeological Research Laboratory

Duties: Conservation of the material recovered from two 16th century Spanish shipwrecks

January 1971 to August 1971

Research Associate at the Texas Archaeological Research Laboratory

Duties: Site report preparation and laboratory processing of materials recovered from the 1970 excavation season at the George C. Davis Site, an early Caddoan ceremonial center in East Texas.

June 1970 to December 1970

Assistant Archaeologist at the George C. Davis Site under Dr. Dee Ann Story, The University of Texas at Austin

Duties: Assist in supervising field excavations and teaching a field archaeology techniques course.

Positions (continued)

June 1969 to March 1970

Research Assistant at the Texas Archaeological Research Laboratory

Duties: Field excavation and laboratory processing of archaeological materials from the 1969 excavation season at the George C. Davis Site

Publications

Paper presented at the 3rd Scientific Symposium of C.M.A.S. in London, England, October 9-10, 1973 and published in the proceedings of the symposium: "Electrolytic Cleaning of Metal Artifacts Recovered from the Sea" in *Science Diving International*, ed. N.C. Flemming. Proceedings of the 3rd Scientific Symposium of C.M.A.S., 1973, pp. 96-104.

"Conservation of Metal Objects from Underwater Sites: A Study in Methods", *Texas Memorial Museum Miscellaneous Papers No. 4*, *Texas Antiquities Committee Publication No. 1*., May 1976

"Treasures from the Sea" by Dee Ann Story and Don L. Hamilton. In *Discovery*, vol. II, No. 1, pp. 10-13. University of Texas at Austin. September 1977.

"Conservation Procedures Utilized for the 16th Century Spanish Shipwreck Material". In *The Nautical Archaeology of Padre Island: The Spanish Shipwrecks of 1554* by J. Barto Arnold III and Robert S. Weddle. Academic Press, New York, 1978, pp. 417-439.

Research in Progress

Granado Cave: New Archaeological Evidence on a late Prehistoric Hunting and Gathering Occupation in the Rustler Hills, Culberson County, Texas.

Unpublished Manuscripts

Archaeological Investigations at Shy Pond, Brazoria County, Texas

Preliminary Analysis of the Engraved Sherds and Vessels from the A.R. Hatchell Place, Bowie County, Texas

Preliminary Analysis of Early Caddoan Mortuary Practices

CURRICULUM VITAE

J. Richard Steffy

PERSONAL DATA

Address: 1304 Merry Oaks, College Station, Texas 77840
Date and Place of Birth: May 1, 1924; Lancaster, PA.
Social Security Number: 204-14-3929
Married to Lucille Koch Steffy; two sons, David and Loren

EDUCATION

Pennsylvania Area College, Lancaster, 1946-1947, pre-engineering
Milwaukee School of Engineering, 1947-1949, electrical engineering

POSITIONS HELD

U.S. Navy, 1942-1945
Electrical Contractor, 1950-1972
Kyrenia Ship Expedition, Reconstructor, 1972-1974
Institute of Nautical Archaeology, Ship Reconstructor, 1974-present
Lecturer in Nautical Archaeology, Texas A&M University, September 1, 1976 - present

EXPERIENCE

Consultant, Yassi Ada Expeditions (reconstruction of Byzantine and Roman shipwrecks) of the University Museum of the University of Pennsylvania, 1964 - present
Consultant, Porticello Shipwreck Expedition (study of a 5th century B.C. shipwreck) of the University Museum, 1972
Consultant, THOMAS SKOFIELD Shipwreck (study of a large coal schooner washed up at Sea Isle City, New Jersey), 1972
Advisor, Kyrenia Ship Expedition (reconstruction of a 4th century B.C. merchantman now on display in Crusader Castle, Kyrenia, Cyprus) jointly sponsored by University Museum of the University of Pennsylvania, Oberlin College, and Institute of Nautical Archaeology, 1971
Reconstructor, Kyrenia Ship Expedition, 1972-1976
Co-Reconstructor and project advisor, Privateer Brig Defence Project (excavation of a Revolutionary War Brig near Castine, Me.) of INA, the Maine Maritime Academy, and the Maine State Museum 1975, 1976, 1977, 1978
Reconstructor, York River Excavation, Virginia, 1976
Reconstructor, Serce Liman Medieval Wreck, Bodrum, Turkey, 1978

PUBLICATIONS

"New Drawings of the Yassi Ada Byzantine Ship," AINA Newsletter, Vol. 1, No. 2, 1974, with F. van Doorninck.

"Construction Techniques of Ancient Ships," Naval Engineers Journal, pp. 85-91, October, 1975.

"Technology of Ancient Shipbuilding," Scientific American, purchased but not scheduled.

"The Institutes Model Shop," AINA Newsletter, Vol. 3, No. 1, 1976.

"The Cornwallis Cave Shipwreck, Yorktown, Virginia," International Journal of Nautical Archaeology, Vol. 7, No. 3, 1978, pp. 205-226, with P.F. Johnston and J.O. Sands.

"Construction Details of the Brown's Ferry Ship," Beneath the Waters of Time: Texas Antiquities Committee Pub. No. 6, pp. 55-61, 1978.

"Maximum Results from Minimum Remains," Beneath the Waters of Time: Texas Antiquities Committee, Pub. No. 6, pp. 53-54, 1978.

"The Greek Ship," Naval History Symposium, Annapolis, 1978 (released January, 1979 but not yet received).

"The Coaster at Brown's Ferry, South Carolina," International Journal of Nautical Archaeology, scheduled for May, 1979 (galley proofs approved).

"The Anchors," with F.H. van Doorninck, and "Reconstruction of the Hull," chapters in The Yassi Ada Byzantine Excavation by G.F. Bass, now in publication at Texas A&M Press.

In progress: The Kyrenia Ship and A History of Wooden Ship Construction, books scheduled for 1980.

PROFESSIONAL SOCIETIES

American Institute of Archaeology
North American Society for Oceanic History
The Society for Nautical Research
The Hellenic Institute

MAJOR INVITED PAPERS

American Society of Naval Engineers, 1975
International Conference on Underwater Archaeology, 1977, 1978
Naval History Symposium, 1977
American Institute of Archaeology (invited tour - 7 cities), 1977
The University of London, 1978

During the past five years, served as consultant or advisor to ship projects in Cyprus, Turkey, Wales, Canada, Maine, New Jersey, Virginia, North Carolina and South Carolina.

A&M, joining there geographer Edwin Doran, an authority on watercraft of many regions, but with a special interest in the Pacific and Far East. George Bass and Frederick van Doorninck, Jr., offer courses in the history of seafaring from the preclassical through medieval periods, and J. Richard Steffy teaches the history and theory of wooden hull construction, and the techniques of wooden hull reconstruction; all three continue to devote part of each year to writing and conducting research on behalf of the Institute. Field projects, sponsored mostly by INA, provide students both from Texas A&M and from INA's Supporting Institutions the opportunity to experience excavation techniques and survey procedures that are only mentioned in classes, where emphasis is given to such topics as the economics of ancient trade, the principles of harbor construction, or tactics of Greek naval warfare. The entire program allows students to enter the field of nautical archaeology with a more thorough knowledge of all its various aspects than previously was possible. A major weakness in the academic program, however, has been in the area of conservation.

The faculty in the Department of Anthropology at Texas A&M University and the INA staff, aware of this weakness, jointly recruited Dr. D. L. Hamilton, a conservator specializing in the conservation of material recovered from underwater sites. Prior to moving to College Station last summer, Dr. Hamilton had directed the activities of the Antiquities Conservation Laboratory of The University of Texas at Austin for seven years. During that time he was responsible for teaching conservation classes, preserving all of the material recovered from the 1554 Spanish shipwrecks excavated off Padre Island under the direction of the Texas Antiquities Committee, and conducting research in conservation. The results of his work have been presented in a number of publications, the most exhaustive report being his *Conservation of Metal Objects from Underwater Sites: A Study in Methods*.

Dr. Hamilton now directs the newly established Conservation Research Laboratory at Texas A&M University, where he continues to teach and conduct research, and from which he will supervise on-site conservation for INA and/or Texas A&M projects when the need arises.

A building assigned by the University for Dr. Hamilton's work is now being modified. There remains the long and arduous task of securing the array of chemicals and equipment required of a major conservation laboratory, but already the building is adequately equipped to teach classes, handle standard conservation procedures — such as electrolytic reduction — and work on some outside projects in which students can participate as part of their training. For example, a steel hull plate recovered from the famous Civil War ironclad Union gunboat, the *U.S.S. Monitor*, has been sent to the Texas A&M Conservation Research Laboratory by the Fort Fisher Laboratory in North Carolina. Due to the present lack of facilities capable of conserving the large plate in North Carolina, students at Texas A&M will have the unique opportunity to preserve an important part of American history: a piece of the ship that battled the similarly ironclad Confederate gunboat *Merrimack (C.S.S. Virginia)* on March 9, 1862, and was lost in a storm on December 31 of the same year. When its treatment is completed, the plate will be returned for public display as a visual reminder of this epic engagement and as the earliest example of the revolutionary innovation of ironclad ships.

Dr. Hamilton uncrates a metal plate from the "U.S.S. MONITOR" prior to beginning its treatment at the newly established Nautical Archaeology Conservation Research Laboratory at Texas A&M University.

Photo Credit: Texas A&M University.

The creation of the laboratory comes only two years after the National Advisory Council on Conservation pointed out the critical need for additional conservation facilities, trained conservators, and educational programs for teaching the processes of treating archaeological material. The new laboratory is one of only five or six in the United States dedicated to the preservation of material from shipwreck sites, and the only one of its kind in the country where specialized academic courses on conservation techniques are offered.

A concern for the conservation of artifactual materials from the sea results not only from a recognition of the historical and anthropological significance of material recovered from shipwreck sites, but from an awareness that if such finds are left untreated they will suffer irreversible damage and possibly complete destruction. Because it is the responsibility of an archaeologist to see that material recovered from his site is properly conserved, the special value of conservation training for students of nautical archaeology is apparent.

In Dr. Hamilton's courses, students are introduced to the synthetic resins, adhesives and consolidants used in conservation, and are instructed in techniques of

(Cont. p. 6)

CYNTHIA EISEMAN RESIGNS AS EDITOR

The *Newsletter* was conceived by Cynthia Eiseman, who has edited and produced each number since the first appeared in 1973. Ms. Eiseman resigned as editor with the last issue, both in order to have more time for her own research and because, she felt, the center of INA activity had moved from Philadelphia to College Station. She deserves our warmest gratitude for the many thankless hours she devoted to keeping news flowing to our members — it was not easy for her to pry manuscripts from field directors spread over the globe — especially because it was a voluntary effort whose only reward was seeing the INA membership grow and INA grow with it. Until a new permanent editor is found, the *Newsletter* will be put together by those of us who are on hand at any given time. This issue is edited by Kenneth Cassavoy, one of our graduate students at Texas A&M University.

JEREMY GREEN JOINS INA

Jeremy Green first became interested in Maritime Archaeology in 1964 when he participated in the Oxford University Underwater Explorers' Club expedition to Malta. In 1967 he joined Dr. E. T. Hall's Research Laboratory for Archaeology and the History of Art, at Oxford, to develop magnetometers and metal detectors for underwater archaeological work. Green worked briefly with George Bass at Yassi Ada in 1967 and then later with Michael Katzev in Cyprus at Cape Andreas and Kyrenia. In his home waters off Britain he carried out surveys on the Armada ships *Santa Maria de la Rosa* and *Trinidad Valenceria* and the Dutch East India Company ship *Amsterdam*.

In 1971 Green joined the Western Australia Museum as Curator of Maritime Archaeology, carrying out a survey of the 1622 ship *Trial*, excavating the 1656 *Verguide Draeck* and then directing 4 field seasons on the 1629 ship *Batavia*. During this period he also joined Sydney Wignall's project *Revenge* in Panama, worked with Colin Martin on the *Dartmouth* and assisted Robin Piercy on the Mombasa Wreck for three seasons.

Currently Green is working on photogrammetric and surveying techniques and the reconstruction of the *Batavia* in conjunction with Richard Steffy of INA. He also holds the position of Chairman of the Australian National Advisory Committee on Maritime Archaeology. Effective immediately Mr. Green joins the Institute of Nautical Archaeology as a Research Associate.

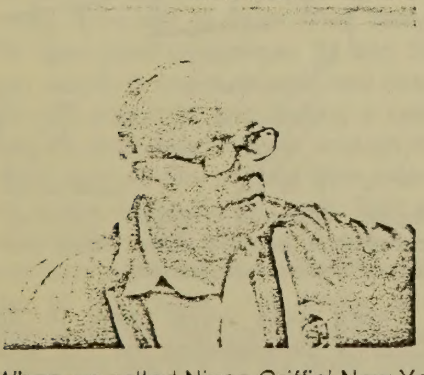
PEOPLE AND PROJECTS

Don Keith and George Bass spent nearly a month in Mexico recently, conducting a seminar on underwater archaeology for the National School of Anthropology and History . . . The Mombasa excavation is getting attention around the world, with major articles cropping up in the Athens News, Cyprus Mail, Illustrated London News, and elsewhere. Robin Piercy directed most of the campaign from a hospital in Mombasa; part of the underwater telephone booth had fallen onto his foot at the end of the 1978 Turkish campaign, breaking it badly. He writes from his bed that new INA Research Associate Jeremy Green (from Australia) and Texas A&M graduate student Roger Smith had taken up the slack . . . Roger Smith and Paul Hundley (both veterans of the *Defence* excavation) are visiting the Cayman islands for INA to complete preparations for an underwater survey planned for this summer . . . George Bass recently lectured to the University Museum in Philadelphia, the Dutch Treat Club in New York, the Congressional Underwater Explorers Club in Washington, the Greensboro chapter of the Archaeological Institute of America, and the symposium on ancient trade jointly sponsored by Duke University and the University of North Carolina.

PROFILE

With this profile of Nixon Griffis, one of INA's founding directors, the Newsletter *begins a new feature which will introduce those associated with INA to its members.*

Photo Credit: E. Whitehead.



When we called Nixon Griffis' New York office for biographical material we learned that he was in the Fiji Islands, which was not surprising since once before we had been told that he was studying whales somewhere around Tierra del Fuego. We had been surprised in 1977, however, when he arrived tired and unshaven at Serçe Liman, Turkey, bringing with him travellers' checks to tide the expedition over until cabled funds, somehow lost in the system, arrived at the local bank. Next day he took the first leg of his return trip to New York, six hours in rough seas in an open fishing boat skippered by a nervous teenager.

Nixon Griffis has a habit of turning up in faraway places. He was a working diver during the excavation of the Bronze Age shipwreck at Cape Gelidonya, Turkey, in 1960, and in later years shared the excitements and hardships of Yassi Ada. At that time he was head of Brentano's Bookstores.

George Bass and Nixon Griffis were introduced by Peter Throckmorton in 1960, when Throckmorton was showing slides, in his New York loft, of the discoveries he had made off the Turkish coast. He and Bass were looking for sponsors for the excavation of the Cape Gelidonya wreck. Others were reluctant to back an unproven pair of archaeologists, who proposed excavating an underwater site as if it were on land — especially as the true nature of the site was as yet unknown — but Nixon Griffis gambled, becoming the first individual to support modern, scientific underwater archaeology.

Griffis' love for the sea may be inherited from his great grandfather, Capt. John Limeburner Griffis, who was shipwrecked and nearly starved at sea with Herman Melville. This love continues not only through his association with INA, but in his capacity as a very active trustee of the New York Zoological Society, with a special interest in marine life, and as a past president of the American Littoral Society.

Now 62, Griffis has three children and two grandchildren. When we last saw him, he had a badly cut hand from an ornithological expedition in South America. We expect to see him on one of the INA projects this summer!

HIKMET GÜRÇAY

It is with great sadness that we have learned of the death of Hikmet Gürçay following a short illness. Hikmet Bey was Director General of Antiquities and Museums during most of the years that we have excavated shipwrecks in Turkey. It was due to his understanding that Turkey became the foremost country for underwater archaeology in the Mediterranean, and that a team of Turkish archaeologists and divers is now second to none. Under his overall directorship, the Bodrum Museum for Underwater Archaeology has become a major center for ancient maritime studies.

Hikmet Bey had recently retired as Director General and was serving as an advisor to the Turkish Ministry of Culture. He was a friend, always sympathetic to our special problems, and will be greatly missed by all of us at the Institute of Nautical Archaeology.

– G.F.B.

NAUTICAL ARCHAEOLOGY TOUR

The Institute of Nautical Archaeology is sponsoring a tour of archaeological sites in Greece and Turkey on board the "OREA ELENI", leaving Pireaus on July 7, 1979. Tour guides will be Dr. George F. Bass, Michael L. Katzev and other archaeologists on the staff of INA. The tour will include stops at Mykonos - Delos, with its ancient harbour - Samos - Ephesus (Turkey) - Bodrum, where Dr. Bass will lead a visit to the Museum of Nautical Archaeology - Serce Liman (Turkey), where the Institute is excavating the famous Islamic glass wreck (see National Geographic Magazine, June, 1978) - Marmaris - Rhodes - Thera - and arrive back in Pireaus on July 21. The "OREA ELENI" is a motor sailer carrying a maximum of 38 passengers in 17 double berth cabins and 2 four berth cabins, each with private bath, air conditioning and 110 volt light and electric extensions.

As we go to press some accommodations are still available but anyone interested in joining the expedition, or receiving more information on it, should contact the Institute immediately at 713 - 779-4101.

THE BROWN'S FERRY MODEL

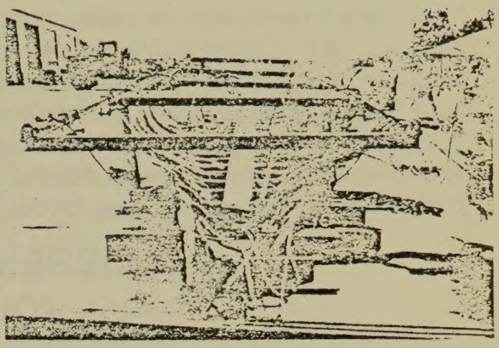
The Brown's Ferry Project was not an INA excavation. We feature it here because it represents an effort on the part of some of our staff which is unknown to many of our members. Each week we are faced with calls or letters requesting help or advice relating to matters in our field. Such inquiries are honored whenever possible. This project is an example of the extent to which such assistance is sometimes carried.

At a conference in Ottawa, I listened to a paper presented by Alan Albright, Underwater Archaeologist for the Institute of Archaeology and Anthropology at the University of South Carolina. A few months earlier he and his crew had spent seven intensive weeks raising this wreck and its artifacts and cargo from the Black River at Brown's Ferry, Georgetown County, South Carolina. Situated in 20 to 25 feet of tannin-stained water and only 25 feet from an old ferry ramp, it was covered with rocks, mud, trees, bricks, the remains of a horse and buggy, and at least two automobiles. It was carrying 25 tons of bricks as final cargo. All 10,000 of these bricks were recovered, along with cooking pots, bottles, smoking pipes, and other crew-related artifacts.

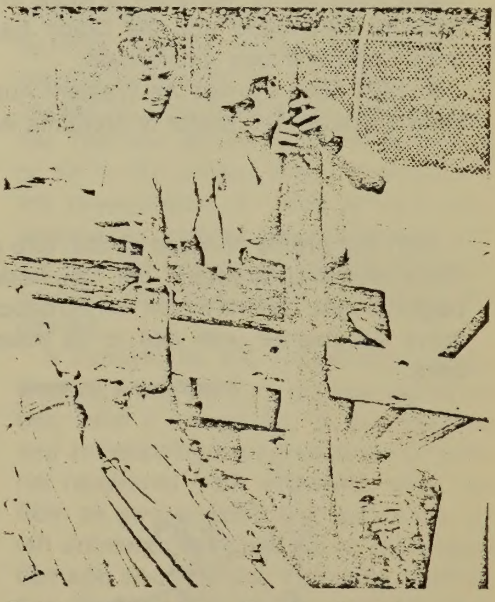
The bottom of the hull and much of its framing had survived as a unit. A large portion of side planking was still loosely attached to this structure. Most of the planking had to be removed separately, but the bottom structure was raised as a unit by suspension from an ingeniously designed metal frame. Limited by time and budget and often faced with seemingly insurmountable obstacles, Alan and his team must be complimented for their successful retrieval of these valuable relics of early Americana.

With the hull raised and stored under water sprays to keep its timbers from drying out, he now turned to us for help. Artifacts dated the wreck to around 1740. Repairs and wear to the timbers indicated the vessel had been built years before. Obviously, this was the oldest preserved hull in America and there were few people Alan could turn to for documentation and reconstruction. We could not conscientiously ignore it.

There were problems. Alan's budget was nearly depleted; ours was zero. We decided to do a low-cost preliminary study at first. Such a study would insure documentation of the merchantman's most important features and perhaps create enough interest to finance the preservation and reconstruction steps to follow. As I was already swamped with academic and Institute duties, it would largely be an after-hours project. Materials and supplies would have to be limited to those left over from previous projects.

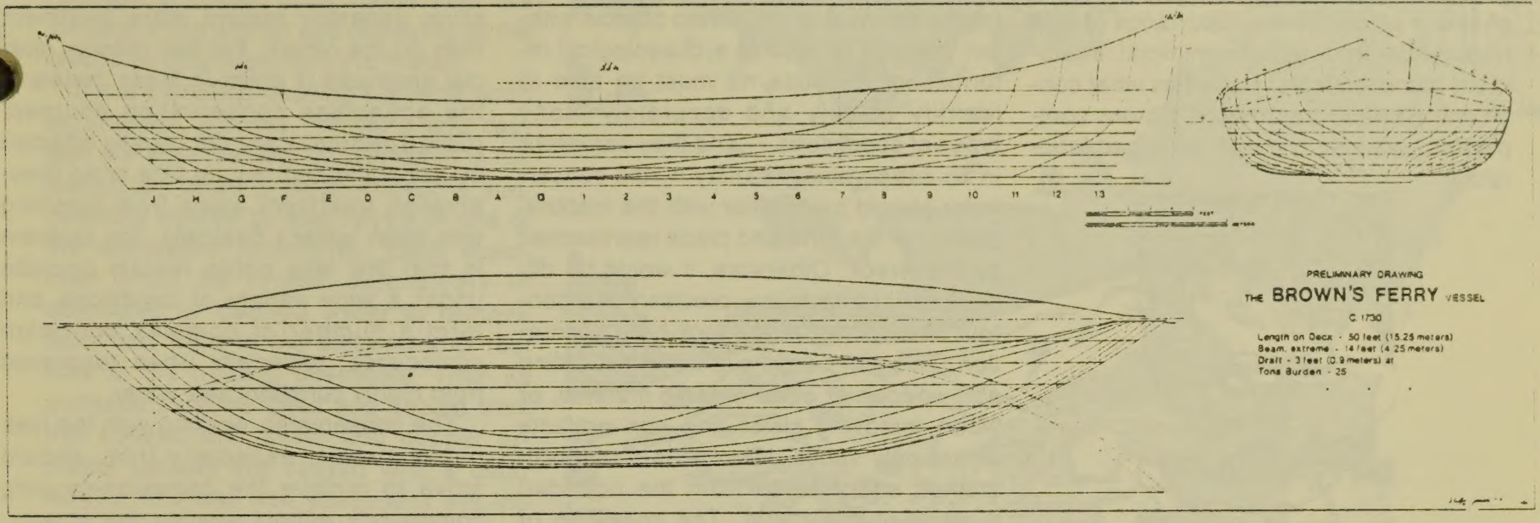


The hull and lifting frame in temporary storage at Fort Jackson. Photo by Alan Albright.



Ralph Wilbanks, South Carolina archaeologist, and the author fitting bow timbers. Photo by Alan Albright.

Three days were spent in South Carolina dimensioning the hull and recording construction features. In College Station, these were converted into hull plans, a five-foot research model, and a report describing the construction features and advising on future work. All were completed within four months.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PRELIMINARY DRAWING
THE BROWN'S FERRY VESSEL
C. 1730
Length on Deck - 50 feet (15.25 meters)
Beam, extreme - 14 feet (4.25 meters)
Draft - 3 feet (0.9 meters) at
Tons Burden - 25

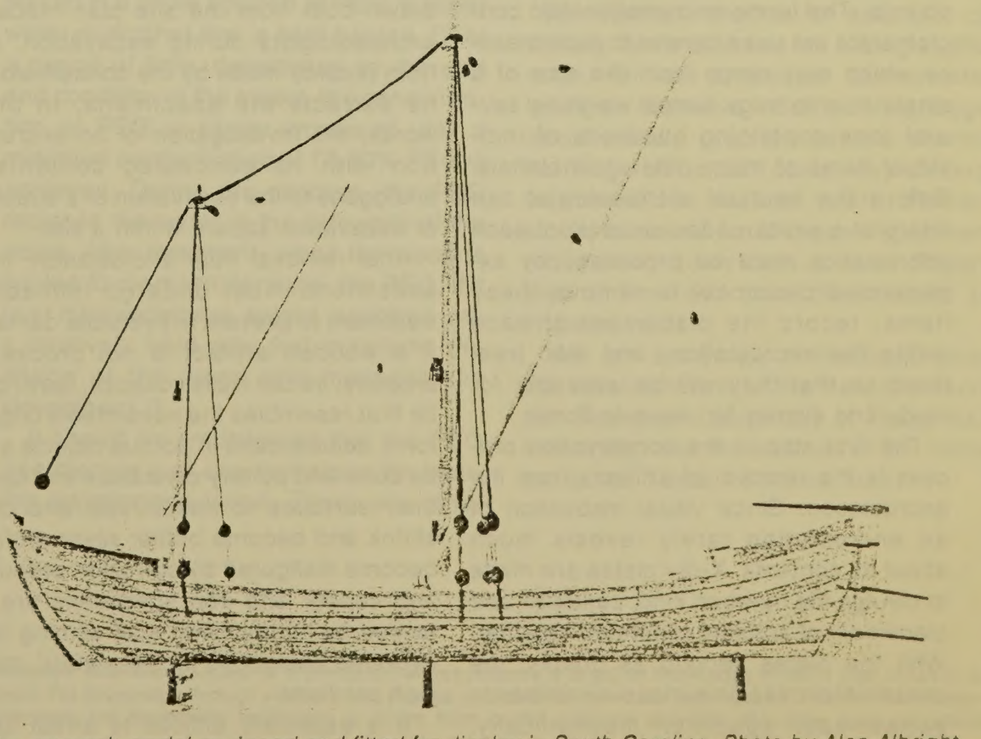
The hull lines. Drawn by J. Richard Steffy.

We didn't stop there, however. Alan expressed the desire that the model be completed beyond excavated evidence, rigged, and sent to South Carolina so that people could better visualize what the Brown's Ferry vessel looked like. We submitted articles to *Texas Antiquities* and the *International Journal of Nautical Archaeology* for publication. And all through the spring semester, the model and drawings were used as teaching tools for nautical archaeology students at Texas A&M University.

Much more information will be learned from the Brown's Ferry vessel once it has been preserved and can be more carefully analyzed. After conservation of the hull is completed, it can be quickly reconstructed and put on display. But already we have learned a great deal about this early representative of coastal transportation. Fifty-feet long at the waterline and nearly fifteen feet abeam, the hull drew less than three feet of water when carrying its rated load of between 25 and 30 tons of cargo. It was a coastal and river vessel, flat-bottomed and lacking a keel so that its draft was shallow enough to navigate over shoals or load from riverbanks where docks did not exist. Built of native woods — oak, pine, and cypress — its members were fastened with a combination of iron nails, iron bolts, and wooden treenails. The quality of construction suggests that not all the good Colonial shipwrights lived north of the Dismal Swamp. It carried a small crew, perhaps two, and had decks only in the bow and stern. We believe its two masts were either sprit or schooner rigged, although these old coasters moved along as best they could by whatever means available. Oars and poles aboard indicated she would have been rowed in calms, poled when drifting upstream with the tide or down with the current, and sailed when nature cooperated with a fresh breeze.

Last June, just before my departure for the INA field school at Castine, the model was prepared for transport. My wife, Lucille intended to accompany me on the trip north but the model and its disassembled rigging took up the entire automobile. Long accustomed to making way for my strange projects, she boarded a plane while the model and I rolled merrily along Interstate 20 headed for Columbia. At a ceremony, the model was formally presented to the President of the University of South Carolina. It has now become a travelling exhibit and is presenily on display in the State House. But our work thus far represents only one step toward the final result. That result will be the reconstructed hull, a proud and permanent symbol of our maritime past.

– *J. Richard Steffy*



The research model as rigged and fitted for display in South Carolina. Photo by Alan Albright.

(Cont. from p. 2)

treating bone, ivory, wood, leather, pottery and the metals of antiquity — gold, silver, copper, lead, tin and iron. Emphasis is placed on the importance of field treatments that require minimal equipment and chemicals, as well as what conditions demand treatment by more complex procedures in a well equipped laboratory.

Graduate student Jody Simmons uses a pneumatic air scribe to carefully remove corrosion from an iron artifact found on a sunken Confederate blockade runner.

Photo Credit: Sheila Matthews

Some of the common problems encountered by the nautical archaeologist were faced during work on material from the 1554 Spanish Silver Fleet, from which many of the following examples are drawn:

When artifacts are recovered from a sunken ship, they are often covered with concrete-like layers of calcium carbonate, magnesium hydroxide, metal corrosion products, sand and various forms of shells, coral, barnacles and plant life which thoroughly disguise the encased objects. The terms encrustation and conglomerate are used to refer to such masses which may range from the size of a single coin to huge lumps weighing several tons containing hundreds of individual items of many different materials. Before the nautical archaeologist can interpret a wreck under excavation, each encrustation must be processed by experienced personnel to remove these items, record the placement of each within the encrustation, and then treat them so that they will be available for study and display for years to come.

The first step in the conservation process is the removal of artifacts from the encrustation. Since visual inspection of an encrustation rarely reveals much about its contents, X-ray plates are made to divulge the number, kind, condition and placement of artifacts concreted together. With the plates serving as guides, the conservator uses pneumatic air scribes to extract each specimen mechanically; notes and drawings record original locations of specimens within encrustations as work progresses.

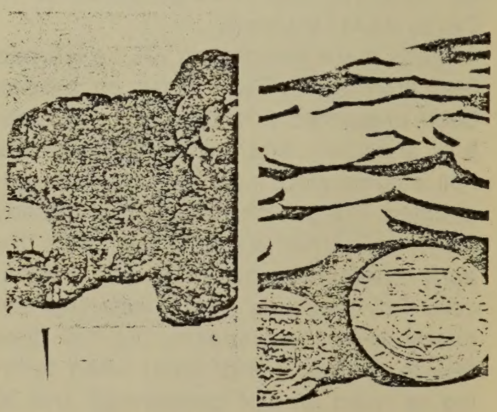
Patience and experience are required for the removal of encrusted objects without damage or loss of archaeological information. Because he must be able to identify quickly and accurately many types of specimens — and they can occur in an extraordinary variety — the conservator should be familiar with the material culture of the time and place represented by the wreck. Otherwise, it would be difficult for him to follow precisely the contour of an object in the rock-hard concretion. This can be difficult when extracting soft wooden or other organic material, or when removing silver and iron artifacts where only subtle differences distinguish stained encrustation from the corroded surface of the metal. The condition of specimens may vary greatly and will affect how they are extracted: many are so fragile that they must be impregnated with a resin before they can be fully dislodged; others may have disintegrated completely, and casts must be made of their impressions or molds left in the encrustations that covered them.

Considerable attention is given to recording the context of artifacts because the types of specimens present, and their arrangement within an encrustation, may be important to historical/archaeological interpretations. From proveniences of artifacts in an encrustation it often is possible to determine much about the nature of a ship and how its contents were stowed, even when few wooden structural parts of the ship remain. Such information is drawn both from the site plan made by archaeologists during excavation, and from records made by the conservator as he extracts the specimens. In other words, the investigation of an encrustation with its concealed contents is analogous to the excavation of a structure or excavation square within a site.

After removal from encrustation, most specimens must undergo immediate treatment to prevent irreversible damage. If a wooden artifact is not processed properly, its cell walls collapse, leaving little that resembles the specimen's original form; soluble salts in porous objects such as bone and pottery crystallize and cause their surfaces to flake; rope and cloth shrink and become brittle; silver artifacts become disfigured by corrosion products; and copper and iron specimens are attacked by hydrochloric acid coming from hydrated cholorides in the metals' corrosion products.

It is especially difficult to arrest deterioration of metal artifacts recovered from the sea. Although the condition of individual specimens of the same metal may vary greatly, artifacts of iron, copper and silver generally require more treatment than do the others. For this reason, special emphasis is given to these metals [illegible] the antiquities conservation courses. (Gold specimens are not usually affected by salt water and require little or no preservation treatment aside from washing with fresh water.) Basically, the problem is that the less noble metals corrode under a wide variety of conditions and form a number of complex corrosion compounds, especially when recovered from highly corrosive sea water.

The conservator, working with the less noble metals, especially iron, should strive to remove the corrosion-causing compounds without altering the appearance of his specimens, and, when possible, reduce the corrosion compounds to a metallic state. Five alternative methods for treating metal artifacts are commonly used: 1) electrolytic reduction, 2) galvanic cleaning, 3) water diffusion, 4) chemical cleaning, and 5) annealing at high temperatures (for iron objects only). Under given conditions, each of these techniques is useful, but electrolytic reduction is the most widely used on all metals and is the only technique that can return corrosion compounds to a metallic state.



Silver coins in encrustation and after conservation treatment.

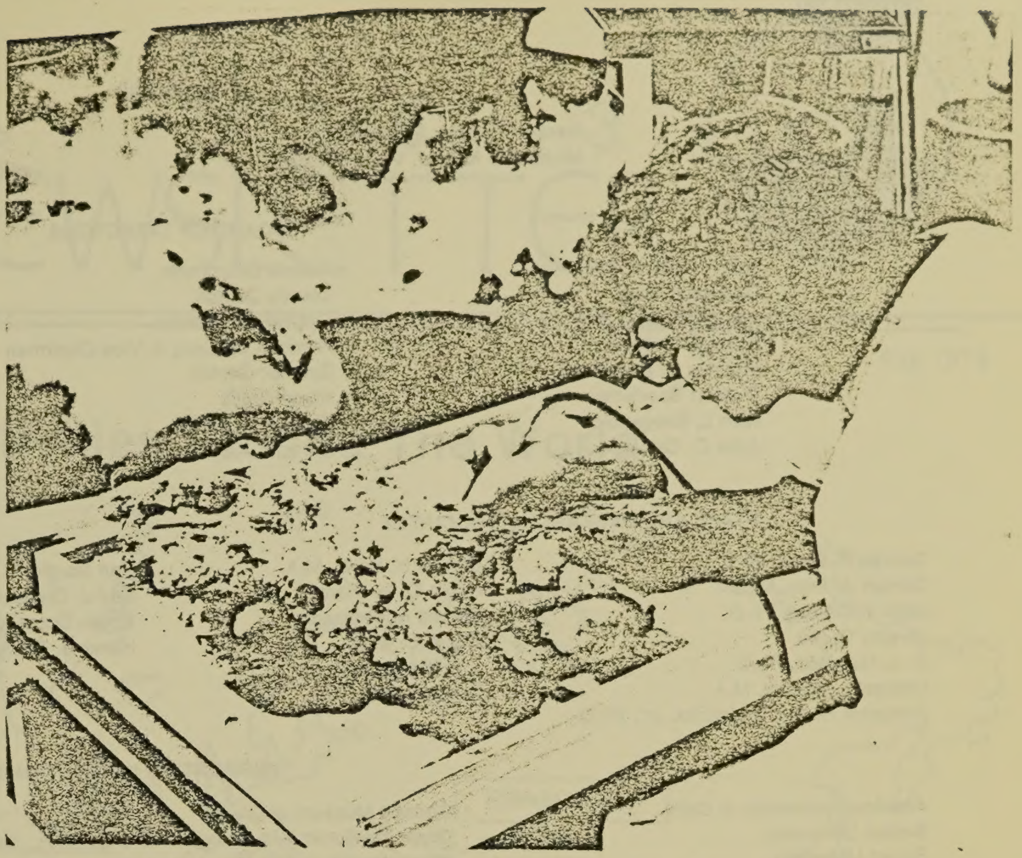
Photo Credit: Texas Archaeological Research Laboratory.

In its simplest form, electrolytic reduction consists of attaching the metal artifact to be cleaned to the negative terminal of a D-C power supply and hanging it between two vertically suspended metal plates in a non-conducting vat. The metal plates are attached to the positive terminal of the power supply. The vat is filled with a conductive liquid such as a 2% sodium hydroxide solution or a 5% sodium carbonate solution. When the current is turned on, hydrogen evolves off the surface of the metal specimen, reducing some of the corrosion products back to a metallic state, mechanically removing unreduced corrosion compounds from the surface of the artifact and removing all the corrosive chlorides from the metal.

Since corrosion-causing elements such as chloride, sulfides, moisture and oxygen are ever present, conservation is not completed when a metal artifact is successfully treated by electrolysis or one of the alternative techniques. Each specimen must be rinsed extensively in deionized or distilled water to remove salts that were in the electrolyte or residue of the treating chemicals. Then its surfaces must be dried and sealed from the atmosphere: silver and copper artifacts usually are coated with a clear acrylic, whereas iron specimens are immersed in molten microcrystaline wax.

Pottery, bone, textiles and botanical specimens such as seeds are also removed from encrustations with pneumatic air scribes, but a layer of encrustation is often left on them to prevent damage to their soft, fragile surfaces. Remaining encrustation and stains are removed with hydrochloric, formic or oxalic acid. Then the specimens are thoroughly rinsed in several changes of deionized water to remove all chemical residues and soluble salts. If the objects have friable surfaces or need additional mechanical strength, they are consolidated with one of several alternative synthetic resins, such as polyvinyl acetate or Acryloid B-72 after they have been dried in a water miscible alcohol.

The conservation of wooden remains has received considerable attention (see Karl Borgin, "Wood in Archaeological Research," *AINA Newsletter* Vol. 2, No. 4). Basically, as long as waterlogged wood is kept wet it retains its shape. If the wood is allowed to dry in air, however, the evaporation of water causes the weakened, water-saturated cell walls to collapse. The conservation of waterlogged wood is primarily a two-fold process involving the removal of excess water by a method that will prevent any shrinkage or distortion, and the incorporation into the wood of a material that acts as a consolidant and confers mechanical strength to the wood. Several techniques exist for the treatment of waterlogged wood, each with specific advantages and disadvantages. The most dependable techniques used in the past few years have been those that use one of the polyethylene glycol (PEG) waxes which are soluble in water and alcohol. The treatment is relatively simple, but the process is often rather lengthy.



With an x-ray plate as a guide, concreted artifacts are removed from an encrustation.

Photo Credit: Texas Archaeological Research Laboratory.

In general, the wooden specimen is placed in a dilute solution of PEG in either water or alcohol that is kept heated. Over a period of time, determined by the size and condition of the object, the concentration of PEG is slowly increased until a minimum concentration of 70-80% PEG is achieved. During the process, the PEG replaces the water in the cell walls of the wood. After treatment, when the wood is cooled to room temperature, the PEG, if it is of high molecular weight, solidifies into a relatively hard wax that maintains the shape of the wood and mechanically strengthens it.

It should be emphasized that the PEG treatment is just one technique for treating waterlogged wood. There are other techniques, such as the acetone/resin method, alcohol/ether, tetraethyl orthosilicate, and others which are often used in given circumstances.

The amount of time and money spent on the conservation of an object is highly variable and depends primarily on the nature of the specimen and its condition when recovered. A silver coin from the 1554 Spanish wrecks, for example, can usually be processed in a single afternoon. An iron anchor or cannon often takes six to twelve months. Waterlogged wood usually requires several months, but large structural parts may undergo treatment for several years. Pottery, stone, bone and small organic specimens require only a few days at most. Regardless of time and cost, the rewards are immeasurable.

We are extremely enthusiastic about the establishment of the new Conservation Research Laboratory at Texas A&M University, and the addition of Dr. Hamilton to the Texas A&M/INA staff.

The American Institute of Nautical Archaeology is a nonprofit scientific/educational organization whose purpose is to gather knowledge of man's past as left in the physical remains of his maritime activities and to disseminate this knowledge through scientific and popular publications, seminars, and lectures. The INA Newsletter is published periodically by INA and is distributed to its members and Supporting Institutions to inform them of INA's current activities. INA is an equal opportunity organization.

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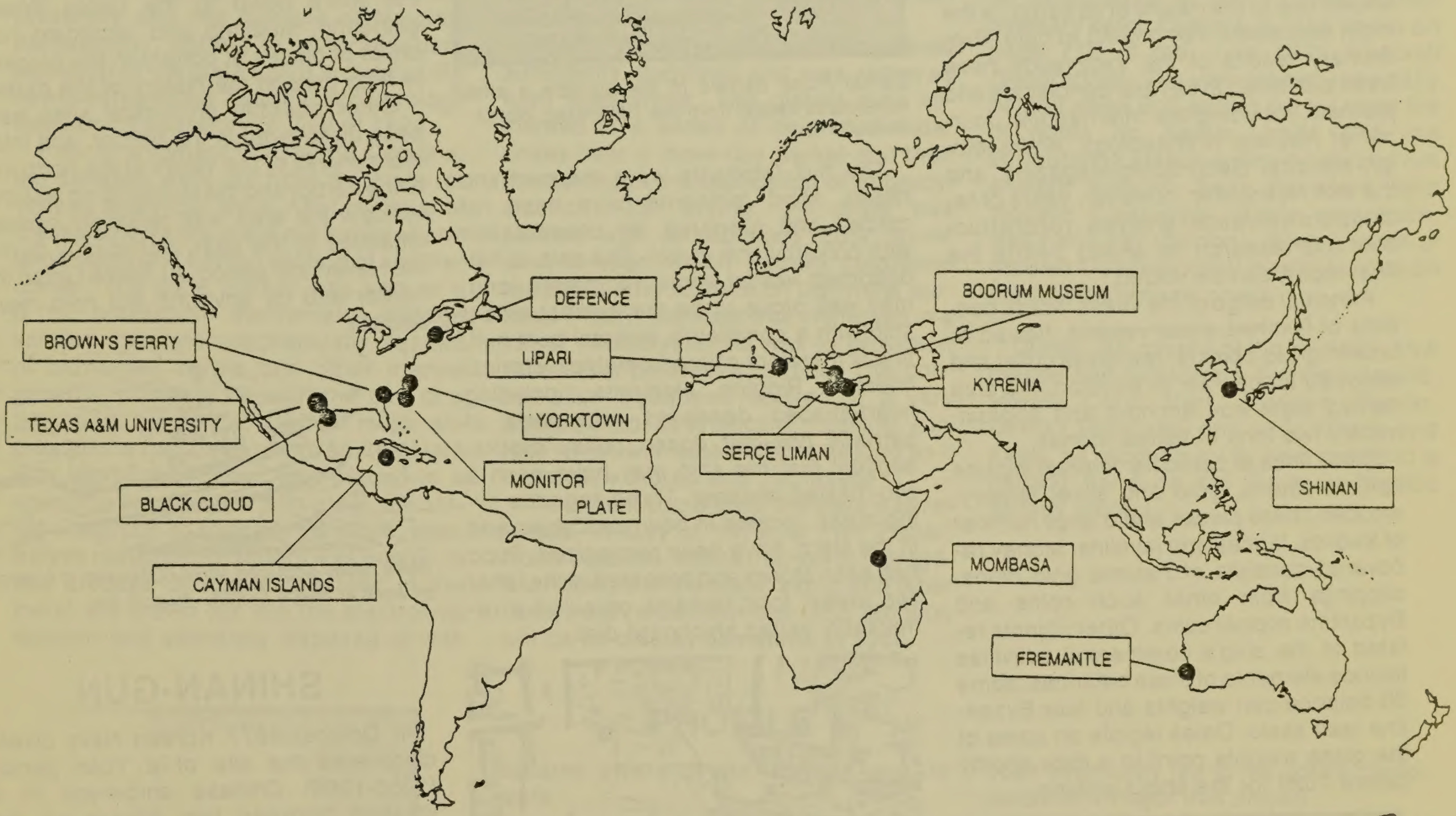
Fall 1979

INA Activities Around The World



Map by: M. Perreault

The close of the last summer field season of the 1970's seems an appropriate time to pause and reflect on the current work of the Institute of Nautical Archaeology. With its headquarters now firmly based at Texas A&M University, the nature and scope of Institute activities has begun a gradual and natural expansion. Devoting the major part of this issue to a review of these INA activities provides longtime as well as newer Institute members, supporters, and friends with a broad view of recently completed and ongoing projects.

A glance at the INA Activities Map indicates the wide geographic range of Institute involvement, while the accompanying text illustrates the diverse nature of INA work on ships and sites dating from the Hellenistic period to the 19th century. Institute activities now range from major, ongoing excavations and field school involvement to furnishing specific conservation help and providing assistance in ship modeling and ship reconstruction for museum purposes.

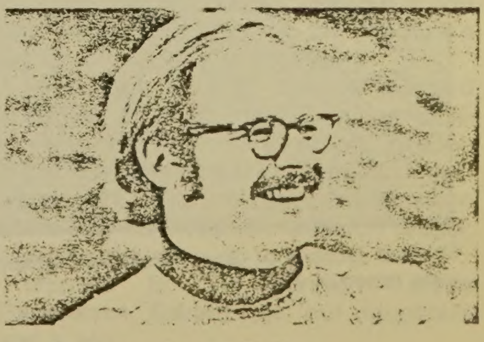
Some of these activities (notably the Hellenistic Wreck at Serçe Liman and the Cayman Islands Survey) will be the subject of major articles in forthcoming editions of the Newsletter. In the meantime, members are here provided with at least an introduction to these and other newly-developing projects, along with a review of more familiar Institute work.

In order to cover adequately all INA work, the Newsletter, for this special edition only, has been expanded to 12 pages.

The following reports were, for the most part, written by the individual Project Directors or by the principals involved in the other activities covered.

SERÇE LIMAN

The medieval shipwreck at Serçe Liman was discovered during the Institute's first project, the 1973 shipwreck survey of the southwest coast of Turkey. Excavation of the wreck, in a depth of about 33 meters, was begun in 1977, con-



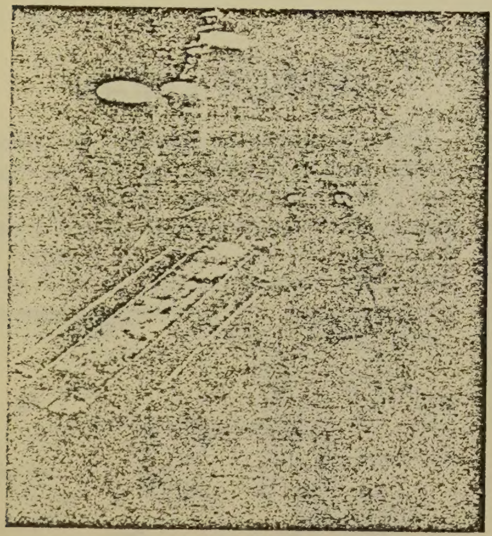
INA President, George F. Bass.

tinued in 1978 and completed during the past summer. In order to ensure proper conservation and analysis of the artifacts recovered, Dr. Fred van Doorninck and a small team of INA staff members, including Texas A&M graduate student Sheila Matthews, remained at the Institute's Turkish headquarters, in Bodrum, following the 1978 season. This continuing work on the artifactual material is being carried out in the Bodrum Crusader Castle where, in recognition of the Institute's work, Turkish authorities have established a museum of Nautical Archaeology and History, under the direction of Oğuz Alpözen.

In the opinion of Dr. George F. Bass, principal investigator, the excavation of the "Glass Wreck," as it has come to be known due to the nature of its cargo, is the most successful INA project to date. Preliminary results of the excavation have been published in several periodicals and journals, including the *International Journal of Nautical Archaeology, Archaeology, National Geographic Magazine,* and the *INA Newsletter*, however, years of tedious conservation, analysis, reconstruction and research lie ahead before the final report can be issued.

Principal cargo of the Glass Wreck consists of finished glass vessels, flawed or broken glass objects, raw glass cullet and about 90 amphoras. In addition, the ship carried eight iron anchors and approximately two tons of ballast stones.

Small finds of particular interest include spindle whorls, gold and silver jewelry, wooden chess pieces and a large number of swords, lances and javelins. Money recovered consists of Fatimid gold coins, clippings from other such coins and Byzantine copper coins. Other objects related to the ship's commercial activities include elements of three balances, some 30 balance-pan weights and four Byzantine lead seals. Dates legible on some of the glass weights point to a date shortly before 1025 for the ship's sinking.



The last sections of Glass Wreck hull remains were raised in 1979.

Cemal Pulak carries to the surface a small handleless vessel from the Hellenistic Wreck. *Photo: D. Frey*

The hull remnants were mapped and raised. Most remnants have been recorded and prepared for conservation with polyethylene glycol. The ship, a flat-bottomed vessel some 16 meters long, may well prove to be the earliest extant ship with a completely skeletal-built hull, and is therefore of considerable historical interest. Rigging elements, including heart-shaped deadeyes and parts of perhaps one-half dozen pulley blocks, suggest that the ship may have been a two-masted lateener. Three separate living areas, located in bow, amidships and in the stern, have been recognized. Food had been stored and prepared in the latter two areas; food remains revealed a remarkably varied shipboard diet.

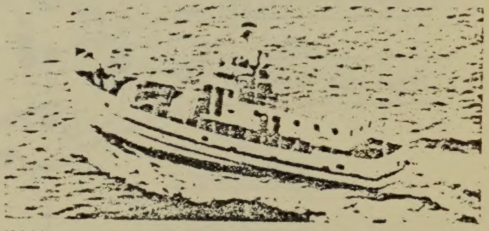
Robyn Woodward working on Glass Wreck material in Bodrum Museum Conservation Lab. *Photo: D. Frey*

While the excavation of the Glass Wreck was nearing completion, the INA group turned its attention to other potential shipwreck sites within the harbor. Cemal Pulak, veteran of several excavation seasons with INA, was placed in charge of testing a Hellenistic (or possibly Classical) wreck site near the harbor entrance. Looted of many amphoras in the past, almost nothing of the site was visible on the seabed before testing began. Removal of deep sand uncovered hundreds of amphoras identified as having been made on the nearby island of Knidos. Beneath these were dozens of small jars, pitchers, bowls, millstones and finally, the first evidence of a preserved hull. Dr. Bass hopes to complete the excavation of this shipwreck in future seasons.

Rhys Townsend, a student at the American School of Classical Studies in Athens who has worked on INA projects in [illegible] Mediterranean and on the East Coast [illegible] the U.S., was placed in charge of studying a potential shipwreck site referred to as the "Scatter Wreck". He was able to identify most of the broken pottery from this badly jumbled site as East Greek.

Dory Slane, a Texas A&M graduate student, and INA adjunct professor Don Frey worked together to produce a photomosaic and plan of the entire seabed from the shore down to the Glass Wreck, gathering, studying and recording hundreds of pieces of pottery in the process, to help unravel the history of the harbor.

Other possible shipwreck sites have been discovered in the harbor, and informal surveys of the valley at the north end of the harbor and the surrounding hillsides indicate the area was relatively densely inhabited in the past, particularly during the Hellenistic period. At Serçe Liman the harbor and its environs still hold many secrets.



INA's newly-acquired VIRAZON used in support of work at Serçe Liman. *Photo: D. Frey*

SHINAN-GUN

In October 1977 Korean Navy divers discovered the site of a Yüan period (1260-1368) Chinese shipwreck in a location between two islands on the southwest coast of the Korean peninsula known as *Shinan-gun*. The divers were working under the direction of government archaeologists who had been urged to come to Shinan by local fishermen after they discovered encrusted, but intact, celadons (a type of stoneware with a blue-green glaze) in their nets, while fishing at the site. The divers managed to pinpoint the remains of the ship in water sixty feet deep, and to raise more than 8,000 artifacts despite strong winds, high seas, fierce currents and the complete absence of visibility under water, before diving was curtailed due to sub-freezing temperatures.

The Navy divers measured the portions of the hull projecting slightly above the bottom, and estimated the ship was about 100 feet long and 25 feet wide.

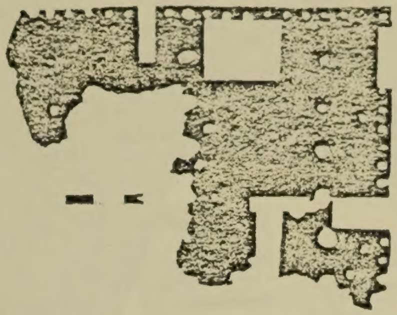
continued on page 4

CONSERVATION OF THE MONITOR PLATE

In August, 1973, the remains of the *USS Monitor* were found, in 220 feet of water, 16 miles off the coast of Cape Hatteras, North Carolina. Following photogrammetric survey of the wreck in 1977, divers raised a number of artifacts from the *Monitor* including a sample of the iron hull plating. The recovery of the plate was undertaken to help develop information on the condition of material on the wreck and to provide insight into the preservation problems which would be involved in the recovery of any additional material.

Dr. D. L. Hamilton, now of Texas A&M University and the Institute of Nautical Archaeology, agreed to undertake conservation of the plate and it arrived at the newly-established Nautical Archaeology Research Laboratory in July of 1978.

Prior to shipment from North Carolina, ten samples were cut from the plate for various analytical tests. After removal of these samples the plate consisted of one large piece and a small section of another corner. The plate initially was kept in a 0.1% potassium dichromate storage solution then later mechanically cleaned of barnacles, corals and other marine growths, primarily through the use of a pneumatic air scribe. After all major encrustations had been removed, the plate was thoroughly rinsed and placed in a specially constructed mild steel vat. Using a solution of sodium hydroxide, electrolytic reduction treatment was begun. In this process corrosive chlorides in the metal are drawn out into the electrolytic solution and ultimately disposed of with each regular change of the solution (see INA Newsletter 6:1).



MONITOR plate after conservation.
Photo: D. L. Hamilton

After 81 days the plate was considered sufficiently stabilized and was removed from electrolysis. The plating was immersed in a series of deionized water rinses over a three-day period and then dried through the application of isopropyl alcohol. After drying, the plate was painted with an aqueous 20% tannic acid solution which formed corrosion-resistant ferric tannate on the metal surface. Finally, the plate was immersed in a vat of microcrystalline wax to provide it with a thin protective coating. The conservation treatment resulted in a very dark colored, aesthetically pleasing, surface which will remain stable as long as it is properly stored and displayed.

Treatment completed, the plate was returned, in May of 1979, to Fort Fisher, North Carolina, where it is now in storage. It is hoped that the plate, along with other items recovered from the *USS Monitor*, will be on display sometime in 1980.

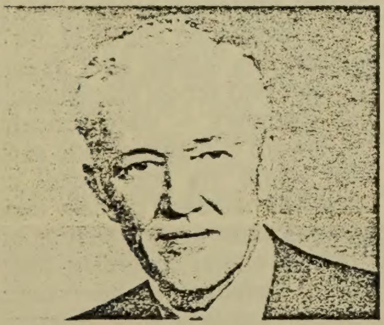
PROJECT VISITORS

The INA summer tour of archaeological sites in Greece and Turkey took 19 participants, including some Institute Board members, to nine locations in those two countries. Highlights of the trip included major stops at the Bodrum Museum and the "Glass Wreck" site at Serçe Liman. The tour will be the subject of a major article in the next issue of the INA Newsletter.

INA members Robert and Cynthia Carter called again at Serçe Liman in their auxiliary ketch *Cynthia R.* (see photo on page 772 of the June 1978 *National Geographic*). The visit proved especially helpful when Bob pulled out his thick file of notes on Serçe Liman and the surrounding area in antiquity, taken from ancient authors, early travellers, and modern Classicists. Bob's new book, *Sail Far Away* (Norton), relates some of his own archaeological investigations on the Mediterranean coast.

During the course of the summer, INA friends and supporters Sumner Gerard, Marcia Cook Hart, Marjorie Parker, David Langworthy and sons Wilson and Keith, all stopped by to visit and lend a helping hand on the Cayman Islands Survey project.

PROFILE



Sumner Gerard. *Photo: Department of State*

During his term as Director of the U.S. AID Mission to Tunisia in the early 1970's, Sumner Gerard became associated with a British underwater group interested in archaeological work. With this group he made his first dive on a Roman shipwreck site. The interest and excitement stirred by this experience and other archaeological activities led him to contact Michael Katzev, INA Vice-President, to investigate the possibilities of cooperating in the excavation of a Roman shipwreck in Tunisian waters. Although this project did not come to fruition, Gerard became aware of the Institute and its work.

Born in Long Island, New York, Gerard was educated at the Groton School, Groton, Massachusetts, and Trinity College, Cambridge, England, where he earned both B.A. and M.A. degrees. He later did post-graduate work at the University of Wisconsin.

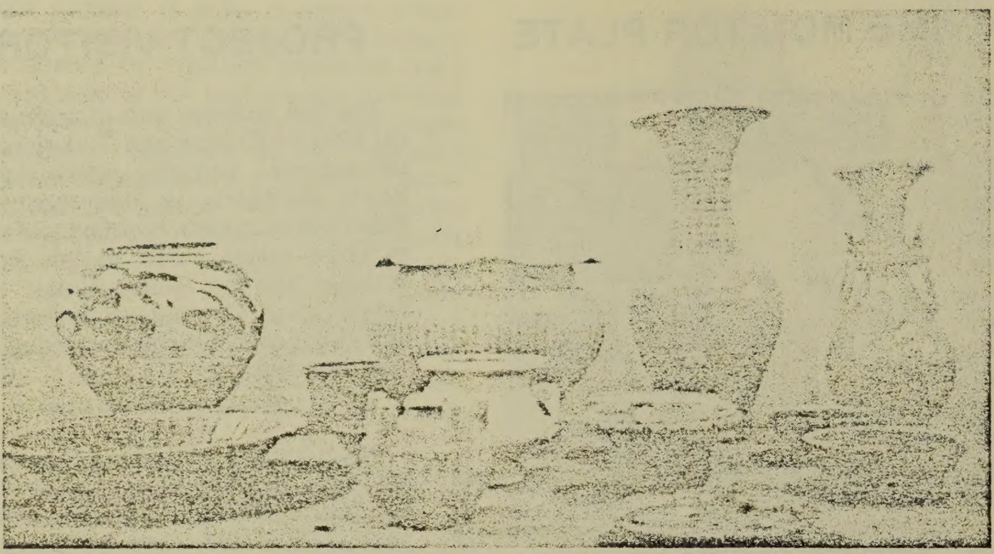
Gerard saw service in the U.S. Army in 1941, and subsequently served as an officer in the Navy and Marine Corps. In 1948 he moved to Montana where he engaged in cattle ranching and business ventures. While in Montana Gerard entered the political arena, serving in the Montana legislature from 1955 to 1966 first in the House of Representatives and later in the Senate.

Gerard entered the U.S. Foreign Service in 1969, working first in Rome, then Tunisia, and ultimately serving from 1974 to 1977 as U.S. Ambassador to Jamaica. His experience and contacts in the Caribbean eventually led to his active participation in a major INA project.

It was natural, Gerard says, for him to contact INA when officials in the government of the Cayman Islands asked him to help them find a scientific organization which could conduct a maritime cultural resource survey of their islands. After INA agreed to undertake the project, Gerard provided strong and enthusiastic support. As the Cayman project began to roll, and his contact with the Institute increased, Gerard quickly became a firm and vocal supporter of the Institute's works, philosophy and goals.

In October, 1978, Sumner Gerard accepted an invitation to join the hard-working INA Board of Directors. Testifying to his commitment to scientific underwater work is Gerard's recent acquisition of the 100-foot, 185-ton research vessel, *Morning Watch*.

Married to the former Teresa Dabrowska, Gerard has four daughters and a son.

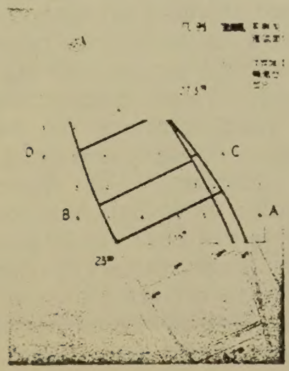


Assortment of ceramics from Shinan-Gun. *Photo: D. H. Keith*

continued from page 2

They reported they had raised only a small fraction of the ship's cargo, so plans were made to return to the site the following summer. Staff members of the National Museum of Korea, in Seoul, who undertook conservation and preliminary analysis of the finds, were amazed at the diversity of the cargo and its degree of preservation. Among the finds were approximately 6,000 Chinese coins; many types of ceramic wares, including porcelains, celadons, earthenwares, stonewares and painted wares; inkstones; grindstones; iron and bronze cooking utensils and tools; silver ingots and cast art objects; a wooden bucket; a bamboo basket; many seeds, including a large number of peppercorns, peach pits and beans; cinnamon bark; fragrant woods; and several wooden packing crates with their contents still intact.

The dates of manufacture of the coins were found to span more than six centuries, the latest of them having been minted in A.D. 1310-11. Since the ship's cargo was composed almost entirely of Chinese products, it was assumed she had been sailing from China. Her most probable destination was not Korea, but Japan, where temples and wealthy individuals collected Chinese art objects on a grand scale.



Plan of Shinan-Gun wreck site.
Courtesy of: National Museum of Korea

Since no shipwreck had ever before been excavated in Korea, and no diving archaeologist was available, advice was sought from outside the country. Korean government officials asked the National Geographic Society to recommend a nautical archaeologist who could travel to the site and consult with the excavators there. The Society contacted the Institute, and I was selected for the job since I had received some exposure to Oriental seafaring in coursework taken under Dr. Edwin Doran, Jr., adjunct professor of the Institute and recognized authority in the field. *National Geographic* provided funding for two visits I made to Korea, and subsequently reported the discoveries at Shinan in the August 1979 issue of their magazine.

Since the original discovery, the Shinan-gun site has been excavated every summer. By the end of the 1979 campaign, the wreck had produced more than 12,000 ceramics and other artifacts, as well as several tons of Chinese copper coins. The scientific committee established to advise and assist the excavators plans to return to the site in June of 1980 to finish the removal of the cargo. The following season will be spent investigating the hull of the ship, which they hope to raise, conserve and reconstruct in a special museum under construction in the city of Kwangju, capital of the province in which the ship was discovered.

It is with keen interest that nautical archaeologists follow the excavations at Shinan-gun. Perhaps the richest ancient shipwreck ever found, both in terms of the modern value of the cargo and the quality, completeness and uniqueness of the archaeological information present, the Shinan-gun shipwreck is also one of the most difficult and hazardous underwater excavations ever attempted.

Donald H. Keith

THE DEFENCE

Since 1975 twenty-nine summer weeks have been devoted to excavating the hull remains of *Defence*, a Revolutionary War privateer that was scuttled in Penobs[illegible] Bay off the coast of Maine in 1779. More than thirty field school students have been involved in the excavation effort, and eleven have returned in subsequent seasons to serve as expedition staff members. The last Newsletter article on the *Defence* project (4:4) was a report of the 1977 field season. Two more excavation seasons have taken place, the most recent during the month of June in 1979. The inventory of finds is presently much more extensive than two years ago. Also since the appearance of the last article, there has been a considerable amount of information gleaned from the hull structure, thanks to the efforts of David Wyman, the assistant director and our structure artist, Peter Hentschel.

The 1978 field season picked up where we left off in 1977. The excavation procedure did not differ from techniques employed earlier. We did, however, incorporate a new theme with regard to the analysis of the structure. Due to the enormous cost of raising and preserving the hull structure, the alternative suggested by the Maine State Museum and the Maine Historic Preservation Commission (under whose auspices the *Defence* project is being carried out) would be "preservation through documentation." This approach involves documenting structure *in situ* and retrieving selected structural items to be drawn and photographed topside. Upon the completion of documentation, these items are registered and reburied in designated repository areas within the hull.

The excavation efforts of the 1978 expedition, the largest ever assembled — fourteen field school students and eleven staff members — were concentrated in the forward mid-section and at the mainmast where the shot locker and bilge pump well had been partially exposed the previous year.

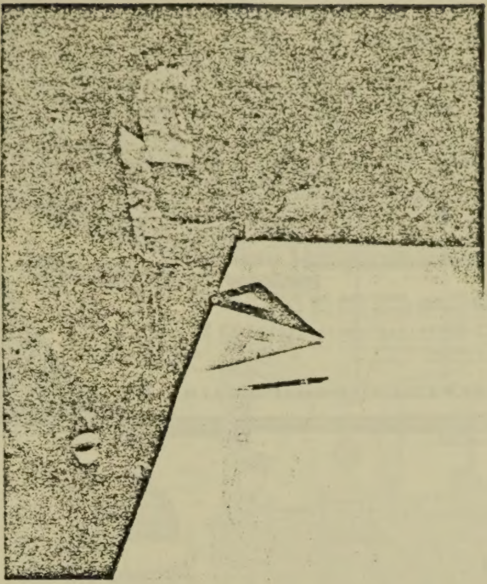
Having earlier confirmed that the bow area of *Defence* had been utilized as a provision stowage area, one goal was to find evidence that her seamen had been berthed in the midship or hold area. Remnants of at least one hammock were recovered, including a wooden support strut and the remains of what appears to be the end of a hammock, a woven or grommet loop with cords which once were attached to the strut. Further evidence of personal items were leather shoes, mess gear — including pewter spoons, buttons, fragments of linen cloth, buckles and buttons, and tobacco pipe bowls and stem fragments.

Also recovered from the forward midship area were numerous sherds of fine or delicate glass bottles. One bottle, reconstructed by Betty Seifert of the State Museum, is a Geneva gin bottle. The others appear to be medicine or pharmaceutical bottles. We had a hint as to their identity even before they were reassembled. One day, as divers were working and the topside crew was sifting through ballast, a strange scent attracted attention. "Smells like moth balls," someone remarked. The origin of the odor was a small glass phial which, still stoppered, contained oil of camphor. Another phial of the same provenance contains a yellowish orange powder. Although chemical analysis has yet to be completed, the material resembles sulphur.

Other unexpected finds from this area included a pair of brass dividers, parts of a Davis quadrant — a sighting vane and a lens, and a Gunter's scale in mint condition. On the day that we were visited by the Director of the Maine Historic Preservation Commission, Earle C. Shettleworth, the excavators — seemingly on cue — came up with intact red ware jars, and a red ware tankard.

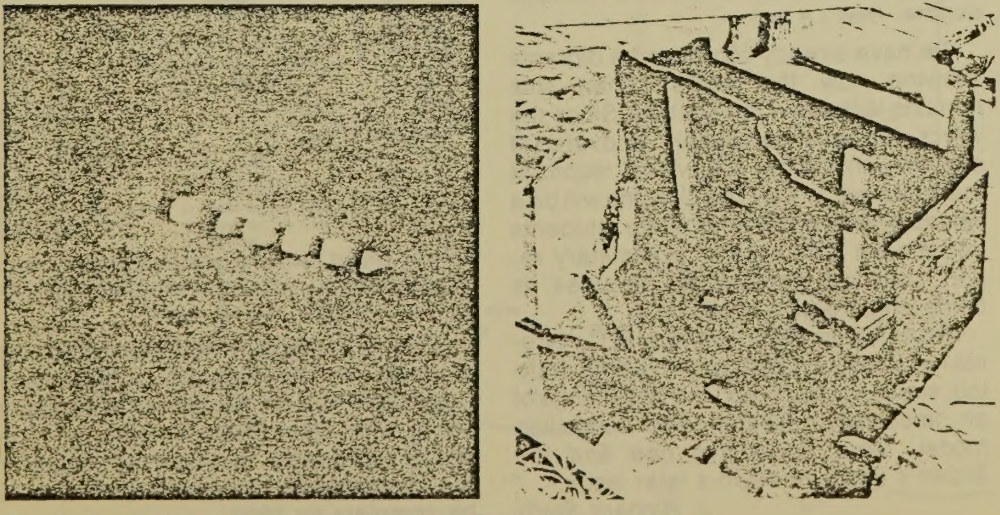
Further aft the finds were equally exciting. In the process of clearing an athwartship trench at the mainmast, the working end of a deck brush was recovered as well as a T grip shovel handle and what has been tentatively identified as the handle of a boarding ax. As the airlift and ballast removal buckets exposed the shot locker and the bilge pump well, the parts of a stave-built tankard (1.8 liter capacity) were revealed — a twin to ones which had been recovered from the forward area.

Of particular interest was the shot locker/bilge well structure. Often depicted in plans, shot lockers, I believe, have yet to be recorded in a wreck. In order to be able to closely examine this unique assemblage of inboard structure, the locker was disassembled board by board. Prior to sending the parts and a bilge pump pipe to the Museum, we reassembled the structure on the float. When checking details to be incorporated into scale drawings we were surprised to find a number of indications of clumsy carpentry — mismeasured boards as well as missing fastenings.



David Wyman with working sheer plan of DEFENCE. Photo: D. C. Switzer

While there are many questions about the shot locker which still remain unanswered, it was possible to gain some insight regarding the construction methods employed in the building of *Defence*. Examination of frames, fully revealed through the removal of ceiling planking, suggest that the privateer was built on the whole mould method. Other bits of evidence such as bark found on some of the frames indicate that *Defence* was sturdily but hastily constructed. She was, however, designed to be a fast sailer. Indications of this trait were found in the bow where the forward most frames are sharply canted with little outward curve. The structural evidence accumulated to date points to the fact that the design of *Defence* closely resembles the "Virginia built" craft of the Chesapeake region. *Defence* may be the first example of the migration of that particular design trend northwards to New England during the 18th century.



Shot locker in situ and re-assembled on work float. Photos: D. C. Switzer

Following the conclusion of the 1978 field season, project participants met at Augusta to discuss future plans. To provide the time necessary for the conservation staff to finish treating artifacts recovered in previous seasons and to get a start on 600 registered finds of the 1978 season, we decided that the 1979 season would focus on further interpretation of the stern-most hull structure rather than the retrieval of finds. During the month of June seven "old hands" returned to Castine and we set out to unravel the complicated jumble of timber in the stern. Further corroborative evidence of the whole mould construction method came to light as frames, deadwood, and a portion of the keelson were retrieved, reassembled on the float, and drawn up in scale.

A number of the mysteries of the stern area were solved; however, the structural interpretive effort is far from complete. As well, there remains much to be done concerning analysis and interpretation of the finds. 1980 has therefore been designated as a study year. We will return to the *Defence* site in the summer of 1981 and during the field season our goal is to complete the excavation of the mud-imbedded hull and complete the process of documenting the hull remains.

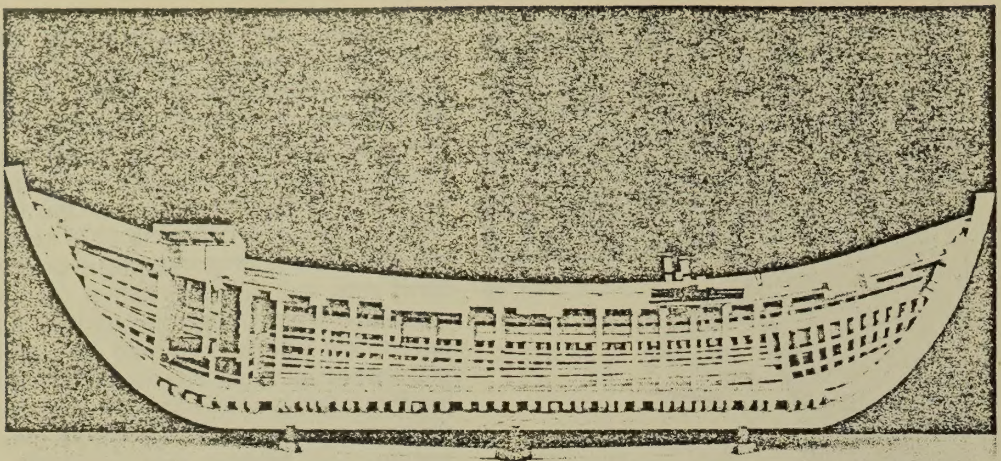
Participants in the continuing *Defence* project include the Institute of Nautical Archaeology, Maine State Museum, Maine Maritime Academy and the Maine Historic Preservation Commission.

David C. Switzer

SHIP RESEARCH

Ship reconstruction continues to be a vital part of INA activities. A dozen projects, representing a time span of 2,000 years, are being subjected to varying forms of research ranging from diorama construction to studies in medieval and classical sciences. This year's most interesting and time-consuming project was the construction of a large scale model of the 7th century Yassi Ada ship. It was built to satisfy several requirements; to supply illustrations for three chapters in the final report of that excavation, to confirm data and construction drawings in the same publication, for the enlightenment of nautical archaeology students in medieval and hull technology classes, and to eventually be placed in the museum in Bodrum, Turkey, alongside artifacts and cargo from the wreck. The model's hull had to be completely visible on the inside as well as the outside and deck.

I decided to build a half-model, incorporating only the port side of the ship and leaving the interior completely open for inspection. Such a model is extremely difficult to build, since it tends to curl into the area of the half which is missing. Construction began last autumn and was com-



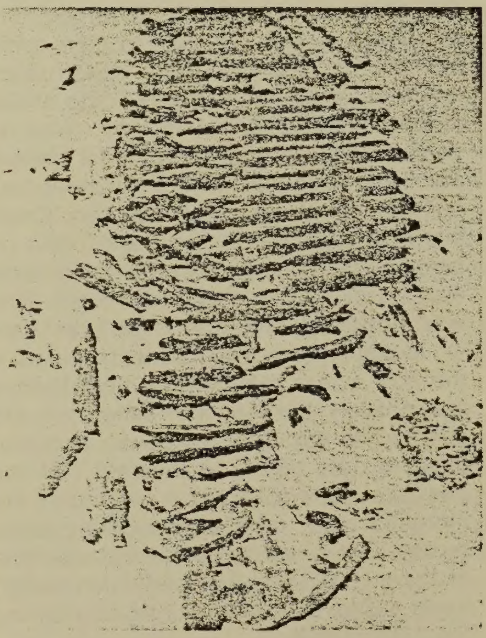
Interior view of Yassi Ada ship. Photo: Bobbe Baker

pleted in May, requiring 1,245 hours of building time. Cost of materials was minimal — about 13 dollars. It is made of pine, weighs only 28 pounds, and is nearly seven feet long. Fabrication followed the same sequence we believe the medieval shipwright used. Each step was photographed for a complete record of the building process. Part of the galley hearth was installed, tiles were placed on the deckhouse roof, and anchors stowed on deck and bowers. Visitors to our workshop were numerous and frequent during the construction process.

Upon completion, the model was "sailed" to the INA Board of Directors meeting in Dallas, floating on air mattresses in the back of a van. Returning to College Station, it was allowed to climatize for thirty days to prepare it for the humid conditions in Bodrum. Meanwhile, a shipping crate demanded almost as much engineering as that which went into model construction. The crate was eight feet long, four feet high, and weighed 160 pounds. Its reinforced interior was designed to prevent shock transmission. More than six bushels of styrofoam peanuts stabilized the half-hull on its cradle within the humidity controlled box. The model was insured for 12,000 dollars, about 80% of its value.

Oğuz Alpözen, director of Bodrum Museum, personally transported the shipment from Ankara airport to the castle in Bodrum, where INA staff were on hand to assist in unpacking and display. We hope it will enlighten visitors there for years to come.

Work on the Serçe Liman medieval hull is progressing at a rapid rate. As drawings arrive from Turkey, wooden hull fragments are recorded and redrawn for our use. Most of the fragments are also modelled in wood for installation in a research model we soon will build. This model will tell us what the old glass carrier looked like, how we should design scaffolds and supports for its reconstruction, what sort of fastenings the original fragments should be attached with, and how to design the reconstruction appointments so that they are in harmony with the rest of the museum environment.



The Serçe Liman hull remains, from a 1:10 scale diorama. Photo: J. R. Steffy

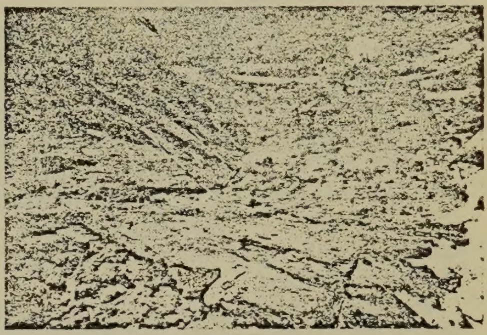
We have already completed a diorama showing how the Serçe Liman ship remains looked on the seabed. Since the wreck was never completely uncovered at one time, this is our only visual record of the entire hull *in situ*. The diorama will be a valuable reference source for students and project staff alike. A preliminary report, detailing construction features, is being prepared for publication.

Research on the 4th century B.C. Kyrenia hull is also in high gear, involving drafting, structural tests, and the beginnings of an important research and exhibition model. More about this one and the Brown's Ferry model in a later issue.

J. Richard Steffy

FREMANTLE

The *Batavia*, flagship of the Dutch East India Company, came to grief on a remote reef off the west coast of Australia in 1629. Her shattered remains lay undisturbed until 1972 when archaeologists from the Western Australian Museum began excavation of the site. Among the wealth of artifacts recovered were 30 tons of timbers from the *Batavia*'s hull. With so much wood recovered the Museum decided to reconstruct part of the hull and place it on permanent public display in a specially designed gallery in Fremantle's new Maritime Museum.



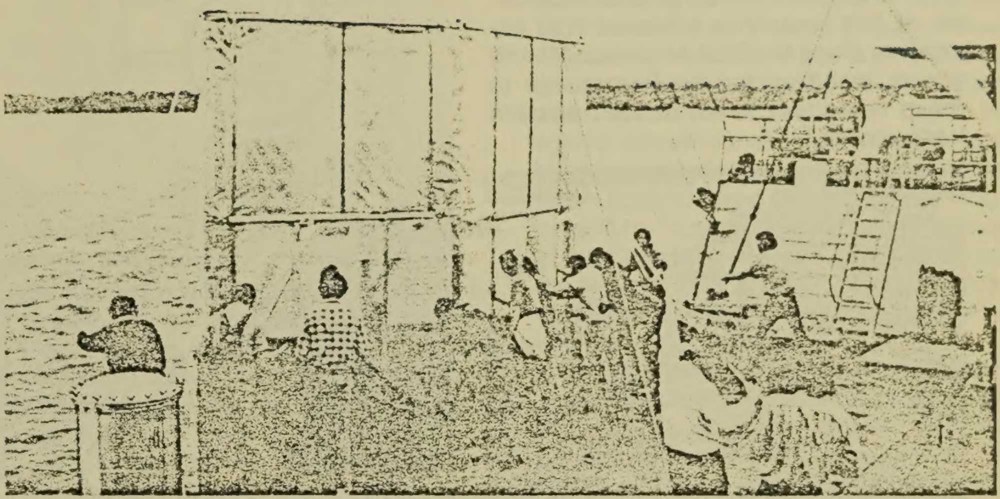
BATAVIA stern section during excavation. Courtesy of: Western Australian Museum

Reconstruction of the *Batavia*'s hull remains has been an international cooperative effort. Western Australian Museum curator of Maritime Archaeology and INA Research Associate, Jeremy Green, visited the Institute's model shop at Texas A&M University earlier this year and received valuable help in planning the reconstruction. Mr. Dick Steffy provided an analysis of the *Batavia*'s hull design and its form of construction, a partial construction plan, lines drawings and a scale model of the recovered portion, as well as suggestions for scaffolding to support the reconstructed timbers.

Jeremy Green (left) and graduate student Paul Hundley work on model reconstruction of BATAVIA stern section. Photo: D. H. Keith

The model made by Steffy and graduate students in the Nautical Archaeology program is now on display in the Museum along with other *Batavia* material. The model represents an important stage in the reconstruction process, which should be complete by 1984.

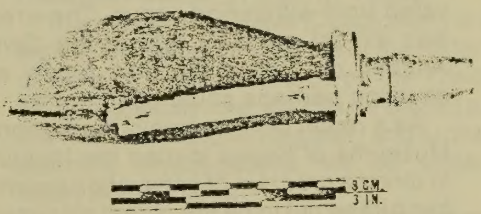
YORKTOWN



Portable cofferdam. *Photo: P. F. Johnston*

In the summer of 1976 the Virginia Research Center for Archaeology contracted for the Institute of Nautical Archaeology to conduct an archaeological survey of a shipwreck in the York River, off Yorktown, Virginia. The project resulted from reports that sportdivers from the area had been diving on the wrecksite and raising artifacts from it of the Revolutionary War period. This led local historians and archaeologists to believe that the wreck might represent one member of a fleet of some fifteen vessels deliberately scuttled by Lord Earl Cornwallis in the fall of 1781 as a defensive measure to prevent an amphibious landing by the Allied forces under Comte de Grasse. This last-ditch effort was unsuccessful, and Cornwallis was forced to surrender to General Washington on October 19, 1781, after the Battle of Yorktown, the last battle of the American Revolution.

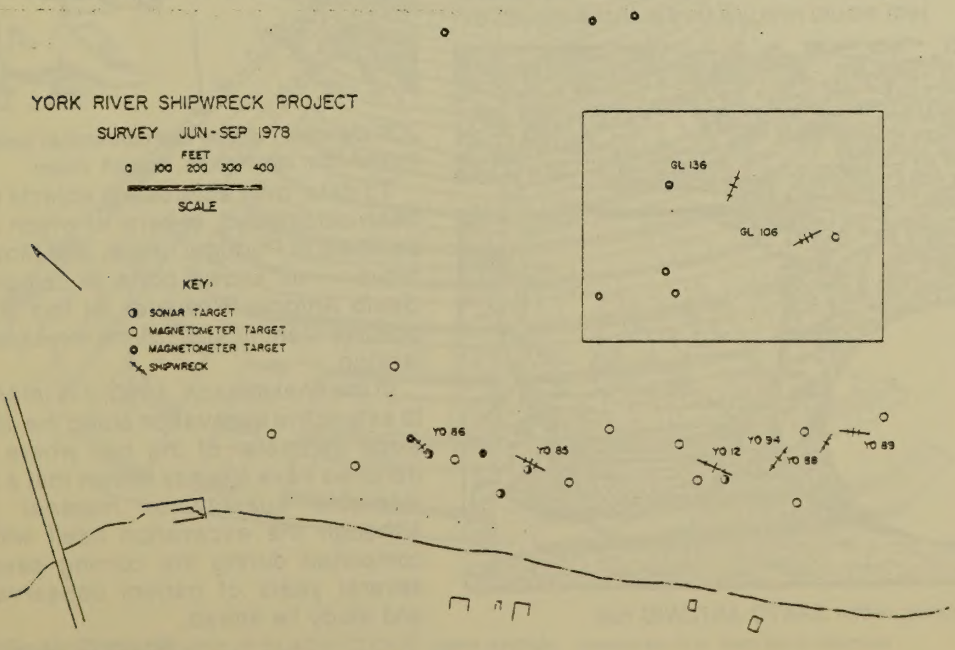
The survey and trial excavation, directed by INA president George F. Bass, lasted from May through July of 1976, and logged 425 man-hours underwater in visibility seldom exceeding twelve inches. The primary objectives were to determine the size and state of preservation of the sunken ship, and to survey the immediate vicinity for further wrecks. Trial trenches were limited to the bow area, which was known to have been disturbed by sportdivers, and to the stern, which was located only after removal of nearly seven feet of overburden, eighty feet upriver of the bow trenches. A large variety of organic and inorganic material was recovered, including the best preserved leather and copper powder flask ever found in an archaeological context. In addition, a considerable amount of information was recovered concerning the ship itself, which was approximately 118 feet long on deck with a capacity of some 550 tons burthen. Since contemporary warships and merchantmen were similarly built, it was not possible to determine to which category the 'Cornwallis Cave' shipwreck belonged.



Powder flask.
Courtesy of: Virginia Research Center for Archaeology

With the completion of the survey, INA's involvement with the Yorktown project ended, although INA graduate students Sam Margolin and Dick Swete have been employed as staff archaeologists under Project Director John Broadwater, who was responsible for the original remote sensing survey in 1976. Efforts in the past few seasons have centered around locating more vessels from Cornwallis' scuttled fleet; to date, nine contemporary wrecks have been found through magnetometer and sonar surveying on both the Yorktown and Gloucester sides of the York River. Of this group two sites are being considered for salvage, due to potential erosion from their proximity to the fast-moving waters of the river channel. Also under consideration is a plan originally proposed in 1976, whereby a steel cofferdam could be placed around one of the wrecks, the water inside filtered to improve visibility, and a pier to the shore built to provide access to the site both for archaeologists and for the viewing public. The prototype for the cofferdam concept was built and tested in the York River during the 1976 survey. Funding for the continuation of the project comes from a 239,315 dollar Maritime Preservation Grant from the Heritage Conservation and Recreation Services. Assistant project director Dave Hazzard reports that additional funding for the next three years is being sought from NEH, and that a major *National Geographic* article is planned for 1981. Further information on the Yorktown Shipwreck Archaeological Project is available from the Virginia Research Center for Archaeology, Wren Kitchen, College of William and Mary, Williamsburg, VA 23185.

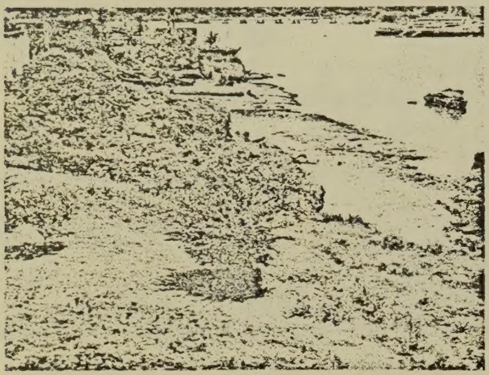
Paul F. Johnston



Map of remote sensing survey results: *Map by: David Hazzard*

MOMBASA

History records that late in 1697 a Portuguese frigate, armed with 50 guns, attempted to break an Omani siege at their stronghold, Fort Jesus in Mombasa. At this time Arab influence was expanding along the East African coast and it was important for the Portuguese to resist this direct threat to their eastern trade routes.



Old Mombasa town harbor with expedition barge over site. Photo: R. C. M. Piercy

This frigate, the *Santo Antonio de Tanna*, came from Goa in India in answer to a request for help from the commander of Fort Jesus. The first attempt to land men and supplies was executed under heavy enemy fire and was only partially successful. The anchorage outside the harbor became untenable due to high winds and the frigate and her support ships set sail for Mozambique to the south.

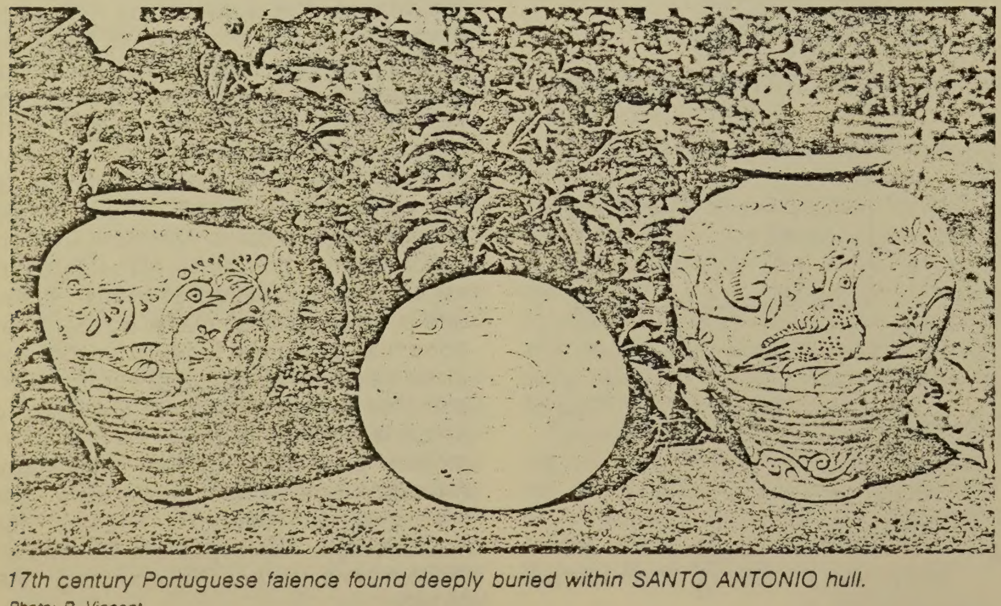
The relieving flotilla returned again to Fort Jesus several months later, only to find that disease had taken a severe toll at the fort leaving only a handful of loyal Swahili and African defenders. Men and supplies were successfully hurried ashore, but due to a series of unfortunate mishaps that followed, the *Santo Antonio* went aground and finally sank off the coral reef in front of Fort Jesus.

Team members record curvature of Keelson.

In 1976 the Institute for Nautical Archaeology was invited by Mr. Hamo Sassoon, of the National Museums of Kenya, to survey a wreck off Fort Jesus and assess the site for further study. At the conclusion of the survey we confirmed the presence of a Medieval vessel similar in size to that of the 50 gun frigate. Materiai which had been raised from the site earlier was contemporary with late 17th century artifacts excavated from within Fort Jesus. The wreck was almost certainly that of the *Santo Antonio de Tanna* but only future excavation perhaps could confirm this.

As a result of the survey, the National Museums of Kenya invited the Institute to direct a program of excavation on what has turned out to be the oldest shipwreck yet found on the east African coast.

It was proposed to raise funds on a joint basis and anticipated that the project would require three, three month excavations. However, at the close of the first season in March, 1977, it became clear that a fourth season would be needed in order to complete work on the site. At this time, three seasons have been successfully completed. The work of clearing and recording the hull has been achieved by staff from INA, the Western Australian Museum, Texas A&M University, Kenyan and British Forces, and volunteers from the United States, Sweden, South Africa, Cyprus and Germany.



17th century Portuguese faience found deeply buried within SANTO ANTONIO hull. Photo: R. Vincent

ZDF German TV crew film cannonball being removed from concretion. Photo: R. Vincent

To date, over a thousand objects have been catalogued, several of which have parallels in Portugal, India, and Mozambique — all known ports of call of the *Santo Antonio*. However, at this stage, positive identification of the wreck is still lacking.

In the final season, 1980, it is intended to extend the excavation along the downslope perimeter of the hull where trial trenches have already shown that a considerable quantity of material lies. Although the excavation itself will be completed during the coming season, several years of patient conservation and study lie ahead.

Robin C. M. Piercy

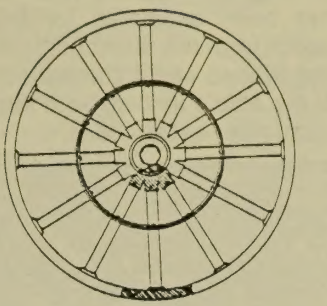
THE BLACK CLOUD

The steamboat *Black Cloud*, a sidewheeler built in 1864 in Orange, Texas, operated on the Trinity River transporting general cargo between Galveston and various settlements along the river. In 1873, after an unusually long career on the river (the normal life expectancy of a riverboat was only four or five years), the *Black Cloud* hit a snag, sank, and was abandoned.

Although the general location of the *Black Cloud* was preserved in the memories of a few of the older local residents, her exact position in the Trinity River was lost until 1965 when dragline operations in preparation for the installation of a pipeline brought up portions of a sidewheel, a hogging chain and other debris. Planned installation of a second pipeline in 1974 made it necessary to accurately define the limits of the wreck site in order to avoid disturbing it further. A remote-sensing survey carried out by the Texas Antiquities Committee accomplished this purpose and the second pipeline was laid without damage to the site.

Graduate students in Nautical Archaeology at Texas A&M University carried out a more detailed investigation of the wreck during two brief periods of field work at the site in the spring and fall of 1978. This investigation was funded by the Sea Grant office at Texas A&M. INA provided assistance in the form of staff support and analysis of hull remains.

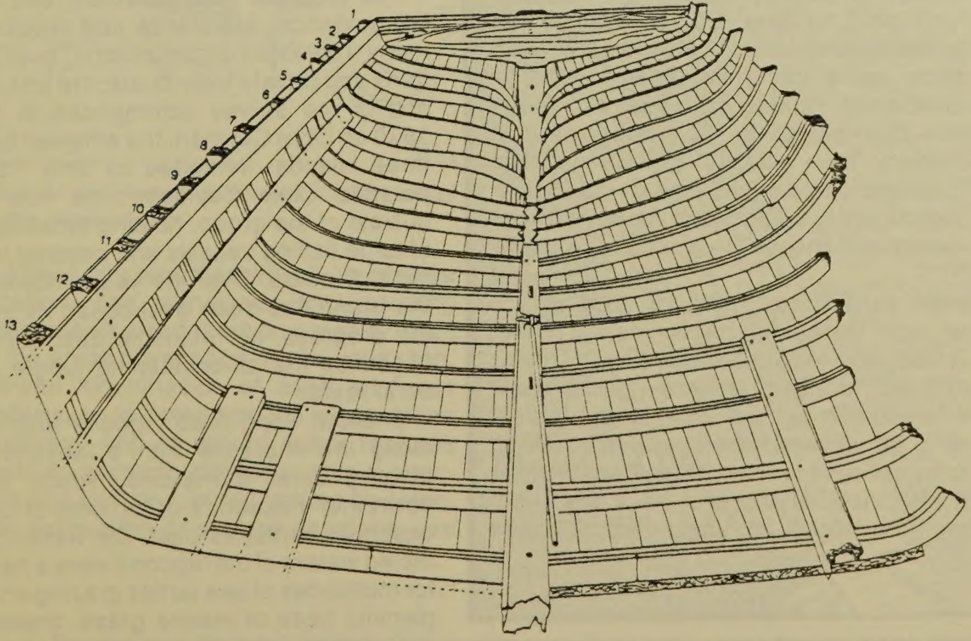
In the course of the field work, a survey of the river bank was conducted to determine the precise location of the wreck. The extent of intact hull remains was assessed and sections of these remains were measured and drawn. Underwater photography was impossible due to the turbidity of the river. Work was concentrated on the intact portions of the hull projecting above the sandy river bottom, which included the starboard forequarter and the entire stern of the vessel.


Reconstruction of BLACK CLOUD paddlewheel. *Reconstruction by: P. F. Hundley*

A full report of the 1978 work was filed with the Sea Grant office, providing maps showing the location and extent of the *Black Cloud* site, illustrations and descriptions of the exposed parts of the hull, and a catalogue of artifacts which includes photographs, drawings and descriptions of the most significant items. All items recovered during the 1978 work were cleaned and conserved in the Texas A&M Conservation Research Lab under the direction of Dr. D. L. Hamilton, and were returned to the Sam Houston Library and Research Center in Liberty, Texas.

The wreck of the *Black Cloud* clearly is a significant resource in terms of the history of transport and commerce on the Trinity River. Hopefully, the site can be placed on the National Historic Register, and further scientific investigations will be undertaken in the future.

Robert Adams

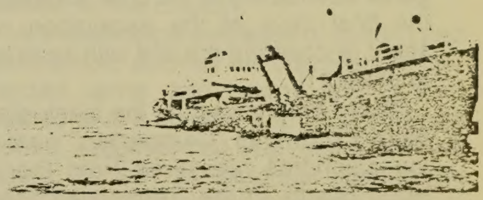


Reconstruction drawing of BLACK CLOUD stern section. *Drawing by: D. H. Keith and S. Matthews*

LIPARI

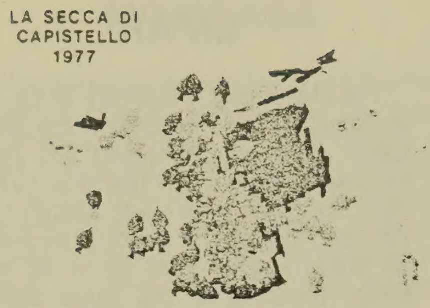
The Hellenistic shipwreck at La Secca di Capistello, off the coast of the island of Lipari, Italy, was surveyed and partially excavated by two INA teams in 1976 and 1977. Located on a steep slope of about 45°, debris from the wreck is strewn over an area ranging from 55 to 88 meters deep. Because of the great depth involved, conventional compressed air scuba diving techniques were not applicable. The sophisticated diving technology necessary to allow scientific investigation of the Capistello site was provided during the two seasons by Sub Sea Oil Services of Milan, an Italian commercial diving company.

With the cooperation of Paola Pelagatti, superintendent of archaeology for Eastern Sicily, Luigi Bernabo-Brea, past superintendent, and Madalena Cavalier, director of the Museo Eoliano of Lipari, Michael Katzev directed the 1976 survey, which determined that the main part of the shipwreck lay between 55 and 65 meters under the sea, with only displaced cargo lying deeper. Sub Sea placed their deep-diving vessel, *NM Corsair*, at the disposal of the survey, as well as the services of ten of their divers, who were undergoing training in the use of mixed-gas diving apparatus.


CORSAIR over site – submarine at surface. *Photo: O. Orzech*

INA staff members Robin Piercy and Donald Frey also dived on the site to provide archaeological control. Although the survey lasted throughout the month of August, the divers managed only a total of five-and-a-quarter hours on the bottom. It was apparent that a full-scale excavation would require the longer working periods on the bottom possible only with saturation diving.

In August 1977, the *NM Corsair* again was moored over the Capistello site, ready to begin a month-long series of saturation dives that would represent the first application of saturation diving technology to nautical archaeology. Don Frey, veteran of the previous season, was present as the INA Project Director, assisted by Donald Keith, Faith Hentschel and Sanna Biehl. In the month that followed, three four-person dive teams provided by Sub Sea spent a total of 21 days in saturation, accumulating more than 157 hours of bottom time as part of their commercial training.

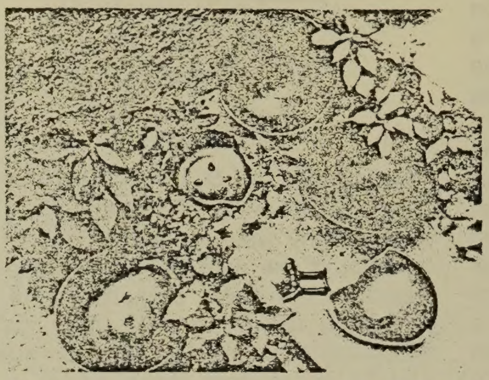


Capistello site plan after 1977 season.
Plan by: D. H. Keith

Because all facilities were pre-empted by the saturation teams, INA personnel could not dive on the site. However, Sub Sea provided them with the use of a one-person diving bell and a two-person submersible equipped with a video camera and recorder. In this way, the archaeologists were able to visit the site and to monitor the progress of the excavation.

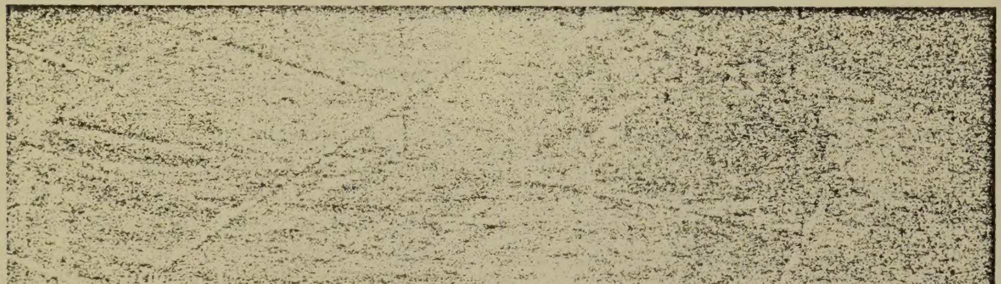
The Sub Sea divers appreciated the significance of their unique assignment and gave the excavation their best efforts. Under the archaeological direction of Don Keith, the divers installed a metal grid frame over the site and began to remove the sand overburden. The extent of the shipwreck site was surprising. Everywhere the divers removed the sand overburden, they discovered amphoras; when they removed the amphoras, extensive hull remains were exposed. It became apparent that the site could not be investigated adequately in the time allotted and the final days of the excavation were spent re-covering the site with sand bags to protect it.

Based on analyses of the black-glazed pottery known as "Campanian" ware and the amphoras recovered from the site, Horst Blanck of the German Archaeological Institute in Rome dated the wreck to the first quarter of the third century B.C. An original length of more than 20 meters has been estimated for the Capistello wreck from the distribution of artifacts on the seabed and a comparison of the size of the ship's timbers with those recorded from other excavations.



Black-glazed Campanian ware from Capistello site.

Although the full archaeological significance of the Capistello wreck has yet to be realized due to the limited nature of the excavation, the collaboration between industry and science, which made the survey and excavation possible, introduces a new frontier for nautical archaeology. As deep diving techniques and equipment are made available to archaeologists — as they were at Lipari — sites deeper than 50 meters will become accessible for the first time. These unexplored sites should contain information in a far better state of preservation than those lying in accessible realms, which so often are irreparably disturbed by looters. By extending the practical working depth of underwater investigations, the nautical archaeologist has multiplied the available resources manyfold.



Capistello site with ship's hull emerging from beneath amphoras and sand – taken from submarine.
Photo: D. H. Keith

THE CAYMAN ISLANDS

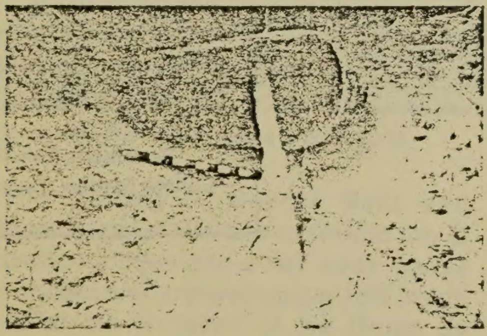
In the spring of 1978, the Institute of Nautical Archaeology was approached on behalf of the Government of the Cayman Islands to discuss the feasibility of an archaeological survey of the waters surrounding this Western Caribbean island group. As a Crown Colony of Great Britain, the Caymans have an Abandoned Wreck Law, which assigns ownership of shipwrecks to the Crown; however, no inventory of potentially significant historical sites has been available to assist in formulating a governmental policy regarding cultural resources. Although island authorities have received applications for commercial salvage of shipwrecks, they have been hesitant to grant licenses without specific knowledge of the archaeological value of sites in their trust. In addition, proposals to build a maritime museum, which would reflect the islands' unique seafaring tradition, have been discussed in conjunction with the newly-formed Caymanian Heritage National Trust.

Although INA previously had not undertaken research in the Caribbean, members of the Board of Directors supported plans for a survey in the Cayman Islands because of the obvious need and because the project would represent an opportunity to provide an example to other West Indian nations of how scientific scrutiny, rather than the hunt for treasure, can bring aspects of national heritage to light. I was invited to direct the Institute's efforts in the islands and proceeded to draft a proposal for a two-season project to inventory and assess shipwreck sites, in order to provide the Caymanian government with recommendations for the appropriate regulation and protection of their resources.

The proposal was accepted, and with the guidance, assistance and support of many interested organizations, business firms and private individuals, the first season of the survey commenced in May 1979 on Little Cayman, the smallest of the three islands. Inhabited by only fifteen persons, Little Cayman once was the busiest of the group, hosting small fleets of turtle fishing vessels and coconut trading schooners. Over the years, however, the island has been overlooked by modern progress, her maritime past camouflaged by the all-consuming jungle and coral reefs.

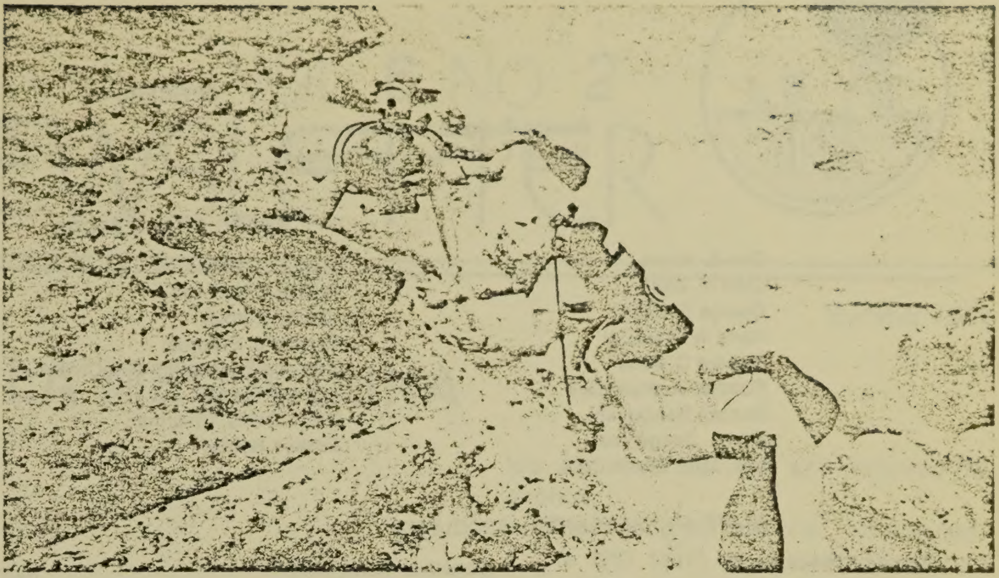
Shallow, sand-filled lagoons alternate along the shoreline with a labyrinth of fringing coral formations, which drop down into thousands of fathoms of open ocean. In centuries past, the warm, protected waters of the lagoons were a haven for multitudes of sea turtles grazing on the plentiful beds of marine grass, breeding unmolested, and returning each year to lay eggs on the quiet beaches. As the region became familiar to mariners during the early stages of New World colonization, Little Cayman's resources and advantageous location along trade routes attracted generations of sea-hardened sailors in need of fresh meat and water or a secure haven in which to refit and repair their ships. However, the island's low profile on the horizon and treacherous reefs represented serious dangers to the unwary mariner. Thus, Little Cayman became known on charts of seafaring men as a convenient but dangerous source of turtle meat and, later, as a sanctuary for loosely organized groups of pirates. Much of this early history has been obscured by time and the remoteness of these islands, affording a challenge to archaeological investigation.

The survey crew, comprised of ten archaeology students and experienced volunteers, set up INA headquarters on the shore of the largest lagoon, South Hole Sound, and organized the necessary boats and equipment for an exploration of the island. Survey strategy included comprehensive coverage of areas most likely to contain shipwrecks — the outer perimeter of the reef, which almost entirely surrounds the island, and certain terrestrial locations, which according to local oral histories, were alleged to have been used by early settlers. A combination of electronic sensing apparatus and positioning systems was employed, in conjunction with visual search methods and local information from island inhabitants, to locate archaeological sites.



Olive jar and heavily concreted musket barrel in situ. Photo: KC Smith

After a site was discovered, its precise location was surveyed from existing benchmarks and plotted on a master chart of the areas covered by the investigation. Careful examination of each site was undertaken to determine the extent of the wreckage and to record major features such as anchors, cannons, ship's structure and fittings. Limited testing by selective excavation or surface sampling was conducted to obtain diagnostic artifacts useful in determining a general date or possible cultural affiliation for each site. These artifacts often included pottery sherds, clay smoking pipe fragments, bits and pieces of the ship's equipment, or crew's possessions. The majority of artifactual material was returned to the area from which it was recovered, after being examined, measured, typed, and photographed. Some, however, were retained for further analysis because of their potential for public display. INA was given temporary custody of these materials, which included a brass thimble, matchlock musket, Spanish olive jar, and various unidentified objects, in order to properly treat them in the new conservation laboratory. They presently are being cleaned and stabilized for return to the Cayman Islands.



Team members measure anchor from a 19th century wreck. Photo: KC Smith

A total of 17 distinct archaeological sites, as well as indications of several others, were encountered on Little Cayman. The remains of small colonial sailing vessels, several merchant ships which struck the reef, 19th century composite-built (wooden hull reinforced with iron frames) trading vessels and modern wrecks all were given the same degree of attention due to the mission of the project, which was primarily to record the character of each site.

The most important discoveries were found buried under the sandy floor of South Hole Sound. A series of sites, tentatively dating from the middle of the 17th century, most likely are the remains of a conflict that took place between the English and the Spaniards over possession of the island. One recorded incident, which needs further historical documentation, occurred in 1670 and represents one of the earliest known battles in the history of the Cayman Islands. A small community of English fishermen suddenly were set upon by a squadron of Spanish corsairs flying false colors; their huts and fishing vessels were destroyed and some prize ships and prisoners were taken. Oral histories relate a similar incident on Little Cayman, alleged to have occurred around the same time, however, the roles are reversed; a "pirate" community was attacked by the English.

Archaeological evidence of conflict and destruction, such as the discovery of discarded arms and spent ammunition, burned ship's timbers and charred turtle bones, suggests that field research in the future, as well as historical clarification from continuing efforts to collect archival information about early island activities, will provide a fuller understanding of Caymanian ancestry. In the meantime, recommendations for the protection of these sites have been presented to the Government of the Cayman Islands in a detailed report of the first season's findings.

Roger C. Smith

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The Institute of Nautical Archaeology is a nonprofit scientific/educational organization whose purpose is to gather knowledge of man's past as left in the physical remains of his maritime activities and to disseminate this knowledge through scientific and popular publications, seminars, and lectures. The INA Newsletter is published periodically by INA and is distributed to its members and Supporting Institutions to inform them of INA's activities. INA is an equal opportunity organization.

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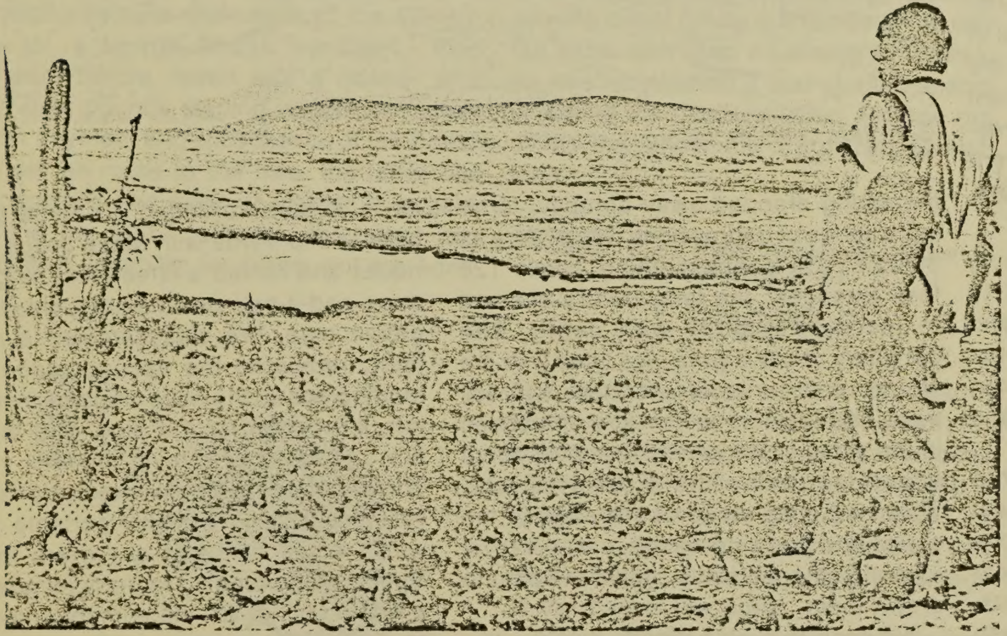
INA NEWSLETTER VOL 6 NO 2

Summer 1979

LA MEDIA LUNA



Co-author Don Keith views Media Luna.
Photo: G. F. Bass

On January 3, George Bass and Donald Keith of INA flew to Mexico City to conduct a three-and-a-half week course in underwater archaeological field methods at the invitation of the Grupo de Buceo Archaeologico de la E.N.A.H. - the archaeological diving group of the National School of Anthropology and History. Here they provide an account of their experiences.

Clouds of steam drifted over the lake, almost obscuring the reeds on its opposite bank and the mountains rising at a distance on all sides. The sound of bubbles popping on the surface was constant. The water, fed from five thermal springs, was far warmer than the chill morning air.

Small wonder that prehistoric people held the Lake of the Half Moon (*la Media Luna*) in awe. Their respect is known to us today by thousands of terra-cotta figurines placed in the lake, often inside pottery vessels.

These offerings had not brought us to the lake. Our three-day visit was only a part of the training course we offered. Every evening in Mexico City, before and after the trip, we gave two-hour lectures, with simultaneous translations from English to Spanish by various members of the class. We discussed the history and theory of nautical archaeology, the history and principles of wooden hull construction, and techniques of underwater survey and excavation, often illustrating specific points with slides and plans of our own past projects.

Now it was time for the students to apply the theories to an actual field project.

Diving instructor Rafael Alducin was comfortable in only a bathing suit as he swam over a survey team thirty feet below. He lifted his head and removed his snorkel:

"They found the first one!" he shouted.

The first team of student divers had done their job well, spotting a solitary sherd of pottery protruding from the lake bed.

We suggested that the second team, armed with stakes, strings and meter tapes, grid the area for photography before beginning the excavation. We left them to decide their methods, and then took turns either snorkeling above them, to observe their work and call out comments, or remaining on shore to record these comments for a later critique.

The newly trained divers made mistakes. It was difficult for them to keep their bodies and fins off the soft bottom which was covered by a thick layer of light, flocculent sediment. Often they were hidden from us and from one another in dark clouds of sediment before the barely discernible current carried it away.

Before the day was over, however, the students had uncovered a two-meter-square area of pottery and were beginning to label each fragment with a numbered plastic tag. The excavation, we felt, would be a success if they continued to improve with each dive on the site.

The site was by no means ordinary. We knew its exact age in advance: it could be measured in hours.

During the long drive from Mexico City

GRUPO DE BUCEO ARQUEOLOGICO DE LA
E. N. A. H.

north to the lake, in the state of San Luis Potosi, we had discussed the training exercise with group leader Pilar Luna, who first had contacted INA about giving the course. The three of us had decided that we had no right, without proper permits and conservation facilities, to touch a single ancient artifact — despite the fact that amateur divers and even misguided archaeologists had raised thousands of figurines from the lake over the years. No plan exists of the original positions of those figurines, a plan that might have allowed scholars to date changes in the level of the lake or shifting patterns of ancient inhabitants.

Instead of causing further disturbance, we decided, we would make our own site.

On the first morning of the "excavation," we had remained in the little farming village of Rio Verde, where several of us had taken hotel rooms, to search the market for our "artifacts": an assortment of cheap, modern, glazed ceramic vessels. Then we jounced over a horrendously pot-holed road to Media Luna, where most of the group had camped.

We arrived to find the others finishing breakfast and making preparations to dive. With the assistance of Rafael and Jorge Rivera, a student from Honduras studying in Mexico, we assembled our equipment on the edge of the *laguna* and began our special preparations.

We broke the modern pottery into sherds, carefully recording the exact number of pieces to be sure that none remained in the lake following our "excavation" to confuse future archaeologists. Then we placed the sherds into mesh bags and entered the water.

Our teaching plan was simple: we would locate two areas no deeper than thirty feet and "salt" them with the modern pottery. The rest of the group, waiting out of sight of the *laguna* until we were finished, would then conduct a survey to locate the sites. Next they would excavate them, record the relative positions of the artifacts, and finally raise them.

Our first dive in the Media Luna was full of surprises. The water is geothermally heated and practically as clear as the air above. Small fish of unfamiliar species darted through patches of water lilies growing up to the surface from the shallows. At the surface, the water was almost body-temperature and completely unpolluted — an excellent place for practice work.

As we descended, Pilar and Rafael watched us from above. The bottom of the spring dropped away abruptly, forming a series of depressions which were its mouths, the deepest being about 125 feet. Strangely, the temperature seemed to increase slightly with depth. The periphery of the *laguna* was lined with the stumps and trunks of enormous cypress trees, the roots of which were embedded in the sides of the spring at a level about fifteen feet below the present surface. They had once stood at the edge of the spring and drunk its waters, until the level rose at some unknown time in the past to drown them.

G. F. Bass critiques the group at Media Luna.
Photo: D. H. Keith.

We sank to a sill between two mouths of the spring and began to scatter and cover the sherds of three vessels over a small area on the bottom. We placed the last sherd so that one corner stood out to mark the "site." In another area, we repeated the process. We had dived on many sites, but this was the first time either of us had carried artifacts *down* into the water.

Back on shore at the staging area, we presented the group with the problem and stood by while they decided on their plan of action.

On the second day at the Lake of the Half Moon, as part of their practical field experience, we wanted to give the students a feel for the use and theory of the airlift. Unfortunately, funds had not been budgeted for the expensive but necessary low-pressure compressor, hose and lift pipe.

We wondered if they might be able to power a small airlift from the compressed air in a scuba cylinder, so Jorge drove back to Rio Verde with Maria Jesus Rodriquez and rented a fifteen-foot length of three-and-a-half inch diameter plastic irrigation pipe. We disassembled a regulator, removing the second stage and mouthpiece so the hose could be inserted into the bottom of the pipe, and the air flow regulated by turning the tank valve. This simple expedient worked surprisingly well, resulting in a highly portable airlift which could be used anywhere in the *laguna*, often running for forty minutes on a single tank of air. More importantly, the students had learned one of the most important lessons of any field operation — the necessity for improvisation.

During the three-day exercise, the two sites were labeled and photographed with care; Juan Antonio Siller used his architectural training to draw the site plans under water. Although the artifacts were not heavy, we insisted that the students bring them to the surface with air-filled lift bags for the experience. Gabriela Zepeda kept a dive-log, Elsa Hernandez Pons a field notebook, and others kept object catalogues as carefully as if they were recording a true archaeological site.

On the last day, we all had the chance for a new experiment. The steep and soft sides of the *laguna* slid downward into trenches dug by the airlift, preventing excavation deeper than about 18 inches. We suspected that the sediments on the bottom of the *laguna* were stratified, this could not be detected until the sides

(Continued on p. 7)

SERÇE LIMAN AND MARMORICE

With his tongue firmly in his cheek, Dr. Edwin Doran Jr. recently brought to our attention the following sidelight on the INA work at Serçe Liman.

As the INA group began excavations at Serçe Liman in 1977 they (and readers of this newsletter) may have been unaware that a famous naval officer preceded them by 171 years with a somewhat similar "excavation" in nearby waters. In March of 1806 Captain Horatio Hornblower entered the Bay of Marmorice (now Marmaris), only 25 miles northeast of Serçe Liman, in his ship *Atropos* and anchored near the wreck of the *Speedwell*, a former British transport.[1] Five years before, laden with a quarter of a million pounds sterling in gold and silver for payment and subsistence of the British fleet en route to the Nile, the latter had capsized and sunk at anchor in a gale. She lay in 17 fathoms, far below any British capability for diving, but the Admiralty had sent a wreckmaster and three Sinhalese divers from Southeast India aboard Hornblower's ship to make the salvage attempt.

Although the details of the successful effort to bring up five tons of silver and gold make exciting reading the excavation technique was a bit primitive. A keg packed with thirty pounds of gunpowder was exploded to blow a hole in the ship's side, and Hornblower had "... a mental picture of the wreck down there in the translucent water, with her strongroom torn open and the silver in a frozen stream pouring out of it." By standards of the day the excavation was an eminent success, as was Hornblower's feat of seamanship in sailing the treasure-laden *Atropos* out of the bay under the fire of two Turkish forts.

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[1] Forester, C. S., (1953) *Hornblower and the Atropos*. New York: Pinnacle Books.

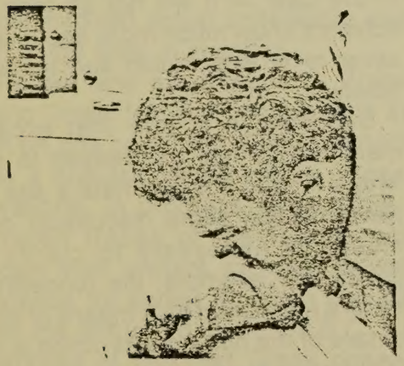
SYMPOSIUM ON ANCIENT TRADE

The Philadelphia Society of the Archaeological Institute of America and the University Museum, University of Pennsylvania announce a symposium on Trade in the Mediterranean in the 5th century A.D. The symposium will be held on Saturday, October 13, 1979, at the University Museum.

Speakers at the symposium will be John Boardman, Ashmolean Museum, Oxford; Lionel Casson, New York University; G. Kenneth Sams, University of North Carolina, Chapel Hill; Homer A. Thompson, Institute for Advanced Study, Princeton; Margaret Thompson, American Numismatic Society; and Peter S. Welles, Peabody Museum of Archaeology and Ethnology.

For additional information, interested persons should write to Cynthia J. Eiseman, University Museum, 33rd and Spruce Streets, Philadelphia, Pa. 19104.

PROFILE



Roger Smith.

In 1971 when Roger Smith, then a senior at the University of Virginia, drove from Charlottesville to Philaldelphia to ask George Bass about a future in underwater archaeology, he was not encouraged at all by the latter's answers. The academic regime, Bass hinted, was long, sober and scholarly, and there were few opportunities to learn and apply skills and knowledge, outdoors, on a site.

These prospects were not a deterrent, and Smith spent the next seven years readying himself for a career in the field. When he enrolled at Texas A&M University in January 1978 in the graduate nautical archaeology specialization, he already had developed, through experience and personal study, a reasonable knowledge and a vigorous curiosity about New World maritime history.

This summer, Smith is directing INA's first archaeological effort in the Caribbean, a survey of the coastal cultural resources of the Cayman Islands. While the project will form the basis of his master's thesis research, its primary value, he says, is in bringing scholarly concern and methodology to the nautical archaeology of this part of the world.

"New World shipwreck archaeology has been dogged in the past by the reputation and actions of treasure hunters," Smith notes. "Not only have these people damaged sites, but they also have influenced popular opinion about the nature and necessity of underwater archaeology. I hope this project will begin to reverse these trends in the Caribbean."

During the June to September project season, Smith's crew of eight will use a magnetometer, radar positioning system, photographic and cartographic equipment, two support vessels and diver inspection of the seabed in their efforts to inventory the shipwreck sites of the Caymans.

Smith's field experience was garnered during employment with several archaeology oriented groups in Florida, including the state's Underwater Archaeological Research Section, where he worked as a field agent for two years before coming to Texas A&M. The latter position gave him the opportunity to survey the wrecks of the 1715 and 1733 Spanish fleets and to work on the excavation of a Paleo-Indian site at Warm Mineral Springs.

In the spring and fall of 1978, Smith joined fellow nautical archaeology students on the survey of a side-wheel steamboat that sank in the late 1800's in the Trinity River near Liberty, Texas. During summer months, he worked with David Switzer in Maine as a member of the *Defence* field school, and spent January and February 1979 in Mombasa, Kenya, working with Robin Piercy on his late 17th century Portuguese site. He was named an INA research associate in the spring.

Born in Utah and raised primarily abroad, Smith says his experience with foreign cultures initially piqued his interest in history, art and archaeology. A commercial diving course and his enjoyment of the ocean helped to channel his direction into underwater archaeology.

Smith describes himself as both a bookworm and an outdoorsman who can be away from either pleasure for only a short while.

"For me, this field has all the elements of intellectual and physical pursuit combined into one. It is an academic synthesis that allows me to work at reconstructing one part of human history while at the same time be outdoors and experience nature on and under the ocean."

BOOK REVIEW

L' Épave romaine de la Madrague de Giens (Var) (Campagnes 1972-1975). By A. Tchernia, P. Pomey, A. Hesnard et al. Gallia Supplément XXXIV. Éditions du Centre National de la Recherche Scientifique, Paris, 1978. Pp. 122, 16 Figs., 41 Pl. 85 F.

In the twenty years or so since French divers, under the direction of Fernand Benoît and Jacques Cousteau, examined remains of a shipwreck at Grand Congloué, French archaeologists now routinely do the work of excavation themselves, rather than merely supervising divers from the surface.

The Roman wreck at la Madrague de Giens is one of several large amphora carriers on the French coast that have been excavated in recent years. During four campaigns, nine and one-half months were devoted to excavation of the wreck marked by an amphora mound some 35 m. long and 10 to 13 m. wide and four months to removal of eel grass and to opening and closing the site annually. Yet it is estimated that only one-fourth to one-fifth of the total wreck has been examined, work having been concentrated in a trench 7 m. wide at the midships section. A remarkable amount of information has been gleaned from this effort, which is presented in an attractive and well illustrated volume worthy of a final publication, although the authors emphasize at the outset that the publication is neither exhaustive nor definitive.

The Introduction locates the wreck, describes its formation on the sea bed, and expressly avoids discussing excavation techniques, on the grounds that methodology has progressed sufficiently that it no longer needs to occupy a major place in publications.

Chapter I is a quick review of the ship's fundamentals: the cargo (wine amphoras and Campanian pottery), the ship's origin (S. Italy) and her wrecking date (*ca*. 75-30 B.C., with a preference for 60-50 B.C.). Chapter II offers a description of how the cargo amphoras and pottery were stowed in the hold. Chapter III suggests that in antiquity free divers worked the wreck to recover part of the cargo. Chapter IV is a description of the Dressel I amphoras which comprise the major portion of the cargo. Included are detailed studies of the shape variations, the stamps, graffiti, the names therein, the social position of free men and slaves and their relative functions in the amphora- and wine-producing industries of Republican Italy.

Chapter V concerns the smaller amount of cargo in the form of Campanian B and C pottery, and follows Lamboglia's typologies. Of four types of common ware ("La Céramique Commune") listed in Chapter VI, only one is described in detail, open forms in red biscuit, as it is the most numerous. This pottery is best known from Gaul, and is so ordinary that it has generally been considered a local ware. Its presence in the cargo of a merchantman sailing from Italy indicates that such was not the case, and we are promised a detailed study of the problems and implications of the phenomenon at some future time.

Chapter VII is devoted to miscellaneous objects, including three lead ingots of Spanish origin; the oldest bronze counter-balance of the Roman world; and a solid lead *amphoriskos* of uncertain function.

Chapter VIII deals with the hull itself, incredibly well preserved under its load of amphoras and layers of sand and eel grass, and admirably illustrated in numerous *in situ* photographs and drawings. Elements of the hull discussed in some detail include the keel, two sets of strakes (inner and outer), frames, mortise-and-tenon joints, keelson, mast step, ceiling planks, stanchions, lead sheathing, and caulking. Observations were made of wood *in situ*, the mast step and some ceiling planks were removed (and later replaced), and a tunnel was run under the hull to permit observation of its external face. In addition, a square meter of the ship's bottom was raised, including keel, strakes, and frames. A good deal of space is devoted to a description of the hypothetical procedure by which the hull was constructed. It is suggested that the inner hull strakes and frames were assembled in five steps which alternate the frame-first and shell-first procedures. If we accept this hypothesis, the Giens ship would thus be the earliest example by some three centuries of this construction method. Moreover, it is noted that other vessels built by the mixed technique proceeded in different ways than the Giens ship.

On the basis of the Giens evidence, we are asked to re-examine some of our long-held notions about traditional Mediterranean ship construction: (1) mortise-and-tenon joints alone do not necessarily indicate shell-first construction; (2) frame-first construction was not entirely unknown in antiquity; (3) the earliest archaeological evidence for active frames goes back at least to the first century B.C., and can be regarded not simply as a transition between shell-first and frame-first construction methods, but rather as evidence of genuine frame-first building; (4) the belief that shell-first gave way gradually to frame-first, and that this change took place some time around the end of the Roman empire must be scrutinized anew.

The Giens shipwreck publication o[illegible] scholars a rare opportunity. In it we are presented preliminary reports on a wide variety of subjects: Roman wine, Latin epigraphy and prosopography, Campanian pottery, wooden ship construction, and maritime trade. The studies, while more comprehensive than those generally appearing in preliminary reports, fall short of what is expected in a final publication. The temptation to criticize — or at least lament — the shortcomings is great. Yet are we not better informed than if we had to wait ten or fifteen years for the project's completion? And might we not do ourselves a favor if, instead, we use the opportunity to convey to M. Tchernia and his colleagues the information which we would like to see in the final publication? Let me cite two examples. I would like to see isotope analyses conducted on all lead and silver items which the wreck produces. If such tests are routinely performed — and to my knowledge they have not been done by French archaeologists in the past — it will not be long before scholars know much more about lead and silver mine exploitation and trade in antiquity.

Secondly, it is true that excavation methodology has progressed to a point where it need not dominate a site report. Nevertheless, some discussion of techniques is necessary to clarify some points. For example, the tunnelling procedure mentioned as a means of studying details of the hull's construction is unique in the short history of ship archaeology in the Mediterranean and deserves a detailed account. Since the technique was vital to understanding the hull construction method, and since the authors present us with a new construction technique, their theory might find firmer footing if the reader has a clearer understanding of how their evidence was acquired.

The excavation of the Giens shipwreck and the publication of this report are exemplary. The studies in the report will be of great use not only to other ship archaeologists but to any scholar concerned with Roman history. Unfortunately, prejudice against "underwater archaeology" is still, in some circles, so very great that this publication might not receive the attention it deserves. Y[illegible] scholars cannot afford to ignore it.

— *Cynthia Jones Eiseman*

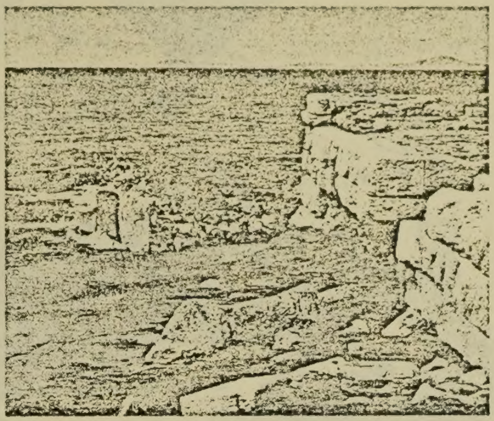
THE GRAVISCA PORT SURVEY

Lisa Shuey (Serçe Liman 1977-78), now a Doctoral candidate at the University of California at Santa Barbara, was a member of the first graduating class in Nautical Archaeology at Texas A&M University. In the following article Ms. Shuey describes her Master's thesis work at the ancient harbor of Gravisca.

The first extensive survey and excavation of underwater remains at Gravisca, located 40 miles northwest of Rome, was undertaken in the summer of 1977. Funded by a grant from Texas A&M University and with additional support from the American Academy in Rome and INA, the project was carried out over a 6-week period by a team of 4 graduate students.

The name Gravisca was known from the ancient sources both as the port of the great Etruscan city Tarquinia and as a later Roman colony founded in 181 B.C.. However, nothing was known about the location or design of the port, and its location in particular has long been disputed by scholars. No less than four different locations have, in fact, been proposed for the port since the 1830's, but none of these involved actual underwater inspection of the sites in question.

Recent land excavations by Professor Mario Torelli focused considerable attention on one possibility, Porto Clementino, now a popular coastal resort. These excavations, in progress since 1969, uncovered traces of the Roman colony known from ancient sources, as well as evidence for earlier Etruscan occupation from the 6th to 3rd centuries B.C.. Large quantities of imported Greek pottery attested to the importance of Gravisca as a center for overseas commerce in the 6th and 5th centuries B.C. and left little doubt that this was the trading station built to serve Tarquinia, located around 3½ miles inland.


Survey area from bastion promontory.

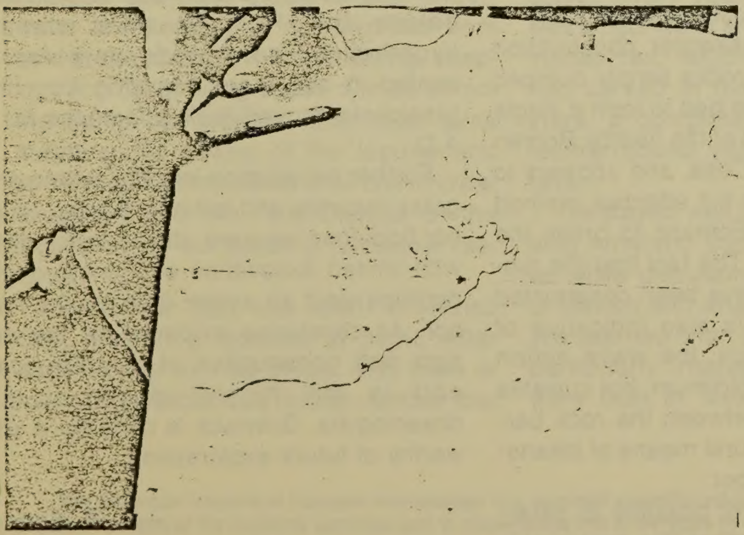
It was also known from the historical record that Porto Clementino served as a medieval and Papal port and that it was improved upon in various periods from the 15th to 18th centuries. No descriptions of these improvements were given in the sources, in fact, the only evidence of earlier port installations visible today are the ruins of a medieval bastion located on the promontory. But one 16th-century report did refer to a breakwater at the port, and it was logical to hypothesize that this structure might have been built over the remains of earlier Etruscan or Roman installations.

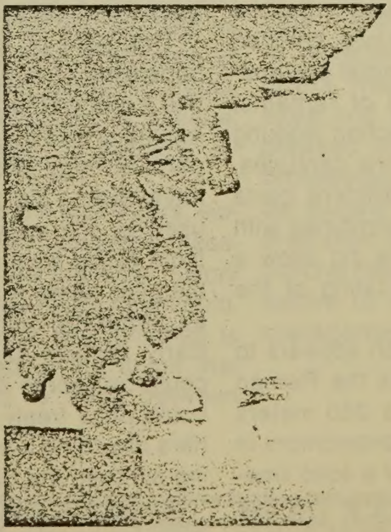
As all these factors pointed to Porto Clementino as a natural location for the ancient port of Gravisca, a thorough underwater investigation of the harbor was requested by Professor Torelli to confirm this hypothesis. With the hope of establishing the port's ancient identity and determining the form and dating of the underwater remains, the objectives of the survey were: to examine and define the presumed area of the ancient breakwater; to map the underwater remains; and then to excavate test trenches to help determine the type of breakwater construction and overall design of the harbor.

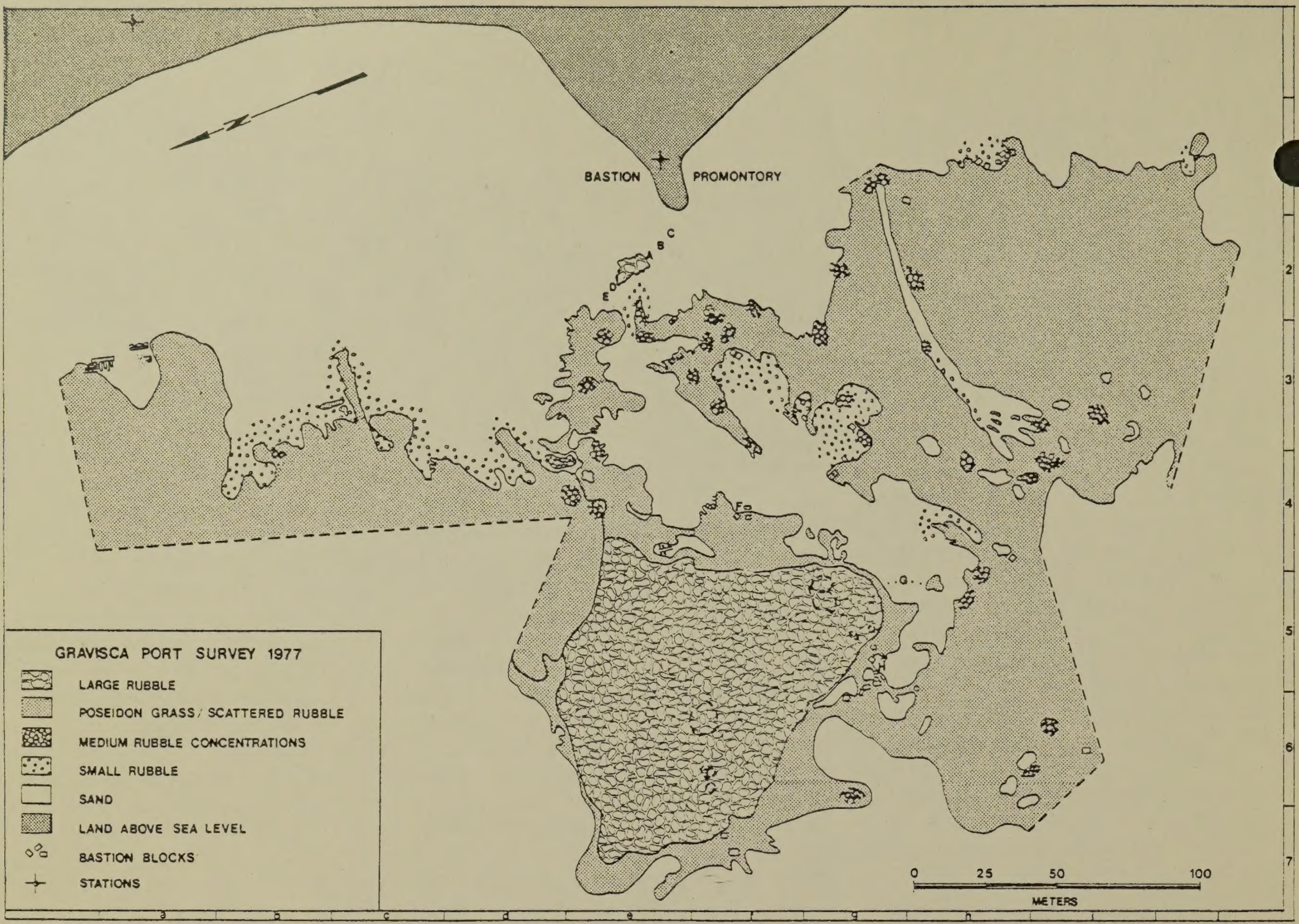
Aerial photographs of the site taken in 1974 were used in the initial stages of planning to help determine the location of underwater remains, which consisted primarily of low, broad beds of *Poseidonia* weed, more commonly called Poseidon grass, and scattered limestone rubble. A series of points were surveyed around these areas by divers holding a range pole over numbered stakes as the points were plotted in using shore-based theodolites. Details of the underwater areas surrounding each point were then measured, drawn, and photographed by the divers, and these data were later incorporated into the final plan.

Partial examination of the underwater remains was carried out by excavation with a shallow-water airlift, a type of lightweight suction dredge. A series of 9 trenches were excavated to depths up to 1.5 meters, both beside and on top of the rubble and grass mounds to examine their morphology, and between the mounds to determine if rubble buried beneath the sand may have connected them in antiquity. Only a small quantity of scattered stones was found between the mounds, suggesting that they were originally constructed as separate rubble mounds rather than as a solid breakwater.

The results of the mapping and excava-


Radial mapping board with polar graph used to correlate underwater data.


Survey team member swimming circular pattern using radial mapping board.



Final plan of survey area.

tion revealed a curious formation of underwater remains presently visible in the area of the harbor believed to have been the ancient breakwater. Low mounds of sea grass and sparsely scattered rubble piles are spread over an area around 300 meters in diameter, which does not immediately give one the impression of ancient harbor works. But the fact that this harbor was heavily bombed in World War II may be a partial explanation of the wide dispersal of remains, along with constant wave action working away at the coastline over the centuries. Comparisons with other ancient ports along the Italian coastline combined with a study of the local currents did allow a partial reconstruction and dating of the harbor works to be made.

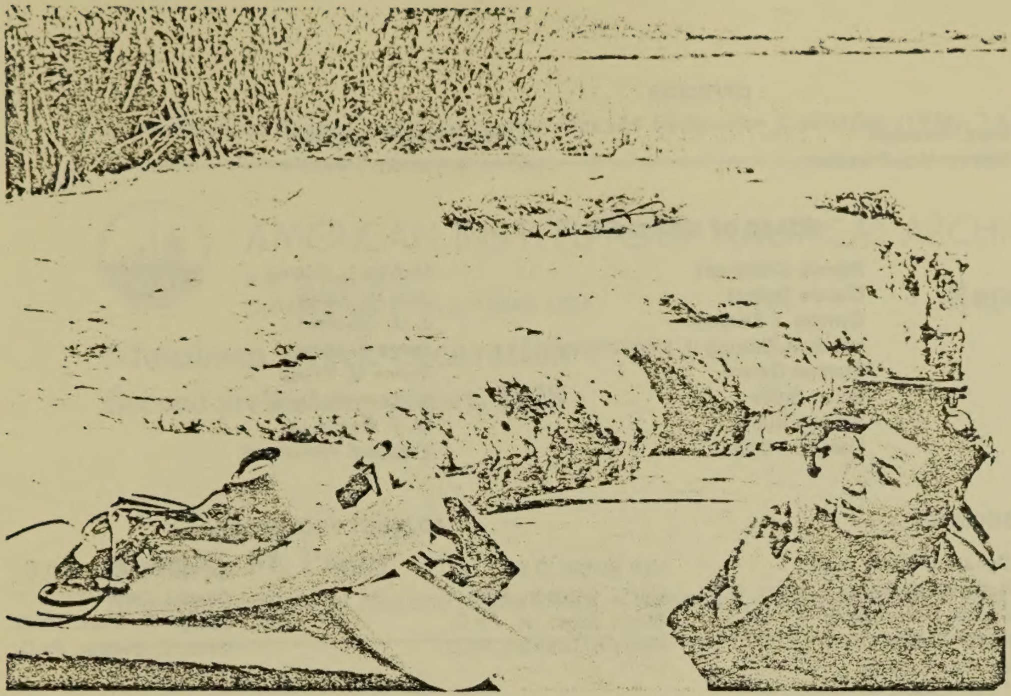
Part of a breakwater which appears to date at least as far back as the Roman period was discovered *circa* 250 meters out from the natural harbor promontory in the form of a large mound of a solid limestone rubble. The top layers of this pile were comprised in some parts of Roman amphora sherds, which were excavated *in situ* from underneath the sea grass growing over parts of the mound. Another smaller mound of rubble was found directly off the promontory, and it is possible that other solid rubble mounds could have existed between these two in antiquity, although only scattered rubble and grass mounds are visible there today.

This type of breakwater construction consisting of large rocks simply dumped into a pile on the sea bed to form a single mound is also found at the nearby Roman ports of Pyrgi and Cosa, and appears to have been a simple but effective method used by the early Romans to break the force of the waves. The fact that the rubble piles seem to have been constructed as separate units is also indicative of Early Roman design; the wave action could be kept to a minimum, but currents could pass freely between the rock barriers providing a natural means of cleansing silt from the harbor.

Although it was not possible to determine for certain whether this breakwater was in fact the original installation in the harbor, the port's identity as ancient Gravisca can no longer be doubted. But despite surface finds from the harbor floor consisting of an Etruscan amphora handle and a 3rd-1st c. B.C. amphora base, the intriguing possibility that the Etruscans built a breakwater at Gravisca before the Romans must remain hypothetical; no periods were represented in our sherd sampling from the breakwater mound itself, prior to the 1st c. A.D.

Further penetration into the rubble and grass mounds and below the sandy harbor floor than we were able to accomplish with limited excavation equipment might perhaps yield an earlier date for the harbor. As conclusive evidence for the design and construction of any Etruscan port is still highly sought by archaeologists, Gravisca is certainly a site worthy of future explorations.

— *L. B. Shuey.*



Pilar Luna, leader of the group, returns from a dive.
Photo: D. H. Keith.

(Continued from p. 2)

of the excavation were stabilized. The students discussed the problem and decided on a plan of action: they would build a cofferdam around three sides of the excavation on the steep submerged slope, and push the walls deeper into the bottom as the excavation progressed. Hortensia de Vega, Gabriela and Elsa brought from Rio Verde a sheet of corrugated asbestos construction material cut into panels one meter wide. Jesus Cuevas floated the panels out to the site and installed them on the bottom, supporting them vertically with iron rods. When the air lift was installed and the excavation begun, the panels held back the loose sediment, enabling the divers to excavate by strata.

An important part of the exercise was to impress upon the students that underwater archaeology is not divorced from land archaeology. When not diving, keeping records, or filling scuba cylinders from the camp compressor, they took turns mapping the shape of the *laguna* and surveying the immediate environs in order to understand the relationships of the *laguna* to its surrounding terrestrial features.

Most of our stay was spent in Mexico City, delivering lectures at night. After each lecture we had dinner with three or four of the students, a limited number that allowed us to get to know them better than was possible in a crowded classroom. Sometimes Pilar Luna introduced us to divers who joined our evening repast and shared their knowledge of Mexico's shipwrecks and other underwater sites.

A special treat for us was meeting Señor Jesus Bracamontes, a naval architect and ship historian who has made the study of the maritime history of Mexico his life's work. One evening was particularly memorable. We had dinner with Señor Bracamontes, then accompanied him to his apartment. His flat was like a museum inside, and it was impossible to absorb and appreciate the amazing collection of objects and literature. Every object, every volume told a story. Here, was a figurine of an Aztec warrior, only six inches tall, which Señor Bracamontes had carved in minute, authentic detail; there, a complete collection of antique, leather-bound volumes on nautical affairs.

We stayed well into the wee hours, sipping Amaretto from tiny, stemmed glasses while discussing the maritime history of Mexico and what the future might hold. We learned that Señor Bracamontes is particularly interested in the ships that were built in Mexico to trade between Acapulco and the Philippines — the Manila Galleons. To understand better their construction features, he made a scale model of the first of these ships built in Mexico, the *San Pedro*, which now resides in a museum in Spain. Señor Bracamontes refers to his three-dimensional work as "miniature ship construction," rather than "model building," and the reason for this distinction was obvious from the examples of his work we saw. Every piece was reproduced faithfully in miniature, and the assembled finished product gave every appearance of having been built by Lilliputians.

Señor Bracamontes finished the evening by presenting each of us with gifts. Don was pleased to receive a facsimile copy of a Mexican treatise on navigation and ship construction originally published in 1587!

Mexico's potential for underwater research is enormous: *cenotes* and springs associated with pre-Columbian civilizations, inundated prehistoric sites and shipwrecks on both the Caribbean and Pacific coasts exist in abundance. But as in most countries, including our own, the predations of amateur divers and professional looters are taking their toll. This was apparent even at Media Luna. Our last day at the *laguna* an American arrived in a plum-colored Volvo bearing Texas license plates. He watched quietly for a while as we worked, then told us we would never find anything where we were excavating. All the "goodies," he told us, were farther along the northeast side of the spring. He made no secret of the fact that he had come to loot the spring and had been here many times before.

In Mexico, as elsewhere, professional archaeologists who are capable of evaluating, excavating, and publishing underwater sites frequently are not able to secure the support and funding necessary to undertake major projects. Week-end divers, meanwhile, pick away at known sites and discover new ones. We are pleased that a younger generation of archaeologists, represented by the Grupo de Buceo, have demonstrated an appreciation for their country's underwater cultural resources, and have taken the initiative to improve their protection and management.

– D. H. Keith
G. F. Bass.

The American Institute of Nautical Archaeology is a nonprofit scientific/educational organization whose purpose is to gather knowledge of man's past as left in the physical remains of his maritime activities and to disseminate this knowledge through scientific and popular publications, seminars, and lectures. The INA Newsletter is published periodically by INA and is distributed to its members and Supporting Institutions to inform them of INA's current activities. INA is an equal opportunity organization.

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Report No. 6

Mombasa wreck excavation

Second preliminary report, 1978

Robin C. M. Piercy
American Institute of Nautical Archaeology, Drawer AU, College Station, Texas 77840, USA

Introduction

This report deals with the second season's excavation of a wreck, believed to be the Portuguese *Santo António da Tanna,* which sank in front of Fort Jesus in 1697. (For 1977 season report see *IJNA* 6: 331–47 and AINA News Letter.

Because of the very nature of the field, archaeology underwater involves an increasing number of specialists. Jeremy Green, Professor Karl Borgin and Wendy Turner are three people whose continuing research is relevant and important. They have all been closely involved in the excavation and their reports are in the appendices. The project was conducted under the auspices of the National Museums of Kenya and continues to be directed by the Institute of Nautical Archaelogy.

The season ran from 1 January through to 31 March. Funding was more generous although running costs were higher as the excavation bore the burden of feeding and housing most of the team in rented accommodation.

Generous local help and assistance again kept costs down.

The excavation

The site was little disturbed by man or weather since the close of the 1977 season. However, the backfill, which was extremely effective, appeared thicker than first thought—perhaps the sea's movement during the year had helped our efforts. The underwater visibility seemed to be poorer than last year especially at high water, caused perhaps by the variable, unseasonable wind and rain.

Fortunately the 27-m long lighter was still available. With a few minor improvements she again served as base for all operations.

As a follow-up to previous work it was anticipated that excavation forward of the mast step would be completed, together with some unfinished areas left from last year, most notably that below the pump box in 20 and 21 H and I, and around 25 H. The intention was also to clear a 6-m wide band down slope on the hull's port side and to complete the detailed recording of the interior hull structure throughout the ship. The latter was to be a continuation of research work started by Jeremy Green in 1977. (See Appendix 1.)

Unfortunately, in order to do this, a considerable amount of backfill had to be removed, as well as vast quantities of ballast stones in 20 and 21 H and I (Fig. 1). Work in the stern around 25 H was slow, due to the complexity of the collapsed internal structure. Once cleared, the after part of the hull was carefully cleaned and completely recorded by stereo-photogrammetry. Profiles were measured at metre intervals (see Appendix 1) in addition to a longitudinal profile of the keelson.

While this work was in progress excavation proceeded in the three sections ahead of the pump box, 17, 18 and 19 F, G and H. The forward pump box bulkhead was dismantled and now awaits future treatment. By the close of the season a further 6 m of keelson and ceiling planking were exposed on either side. Complete clearing of the area was prevented by the presence of a large concretion, approximately

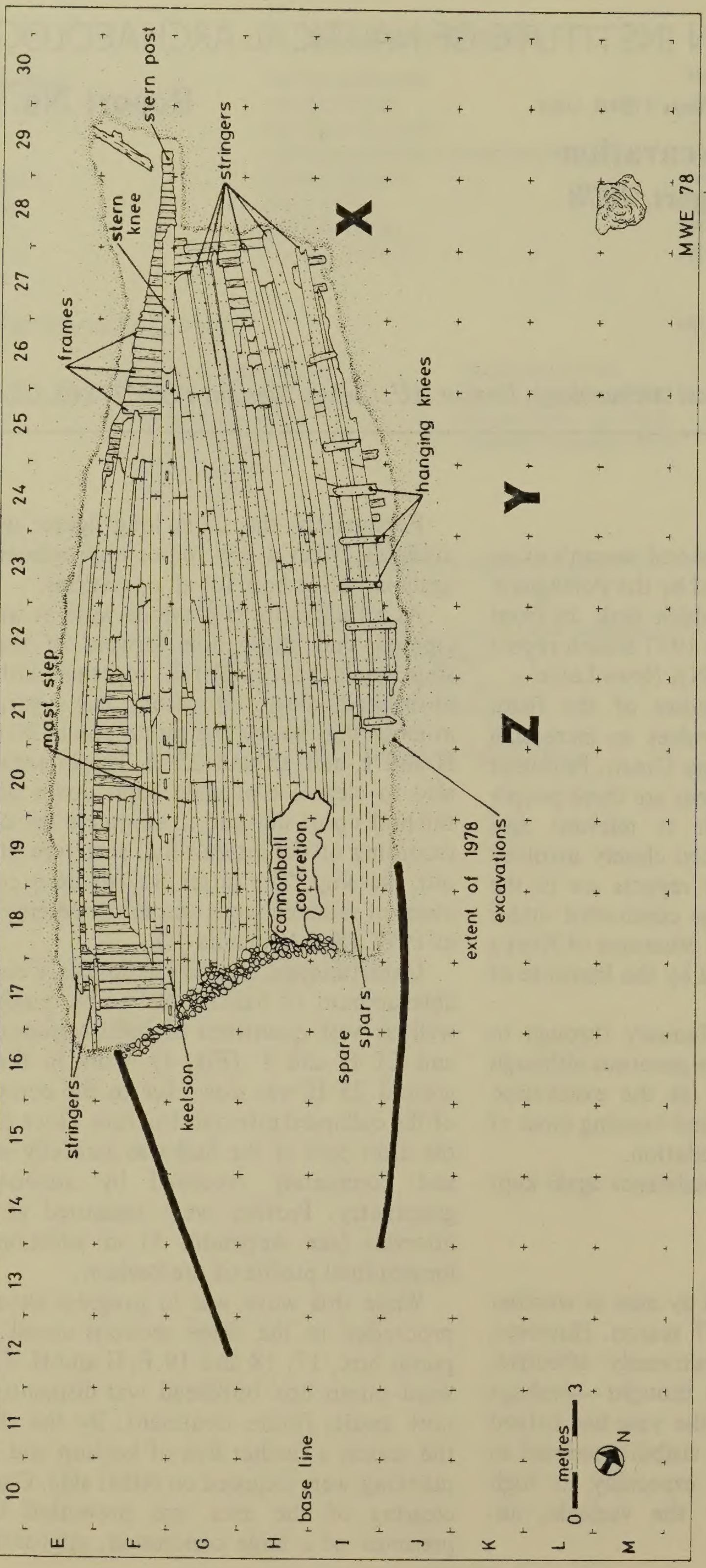
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Figure 1. Plan of ship after 1978 excavations.

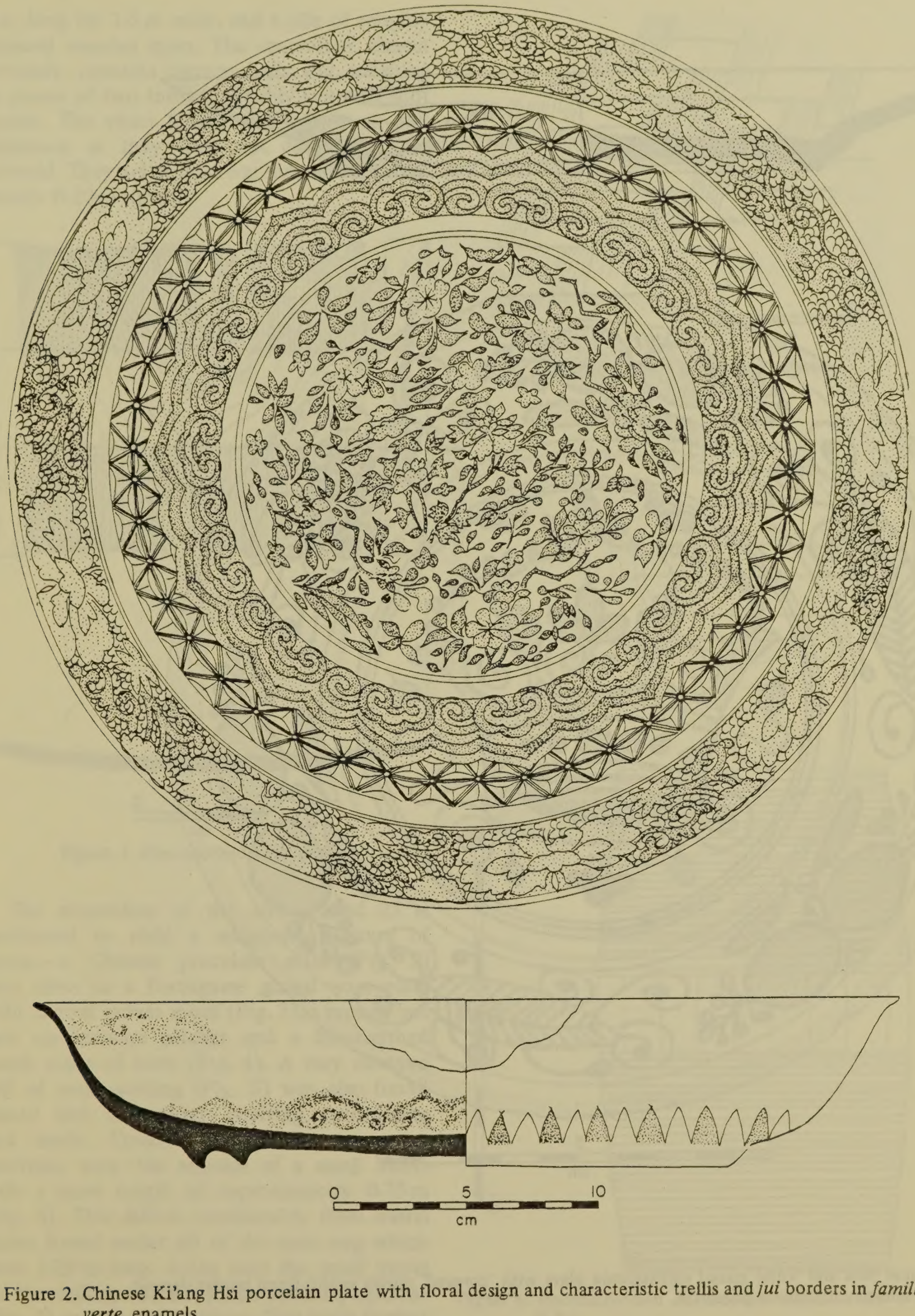

Figure 2. Chinese Ki'ang Hsi porcelain plate with floral design and characteristic trellis and *jui* borders in *famille verte* enamels.

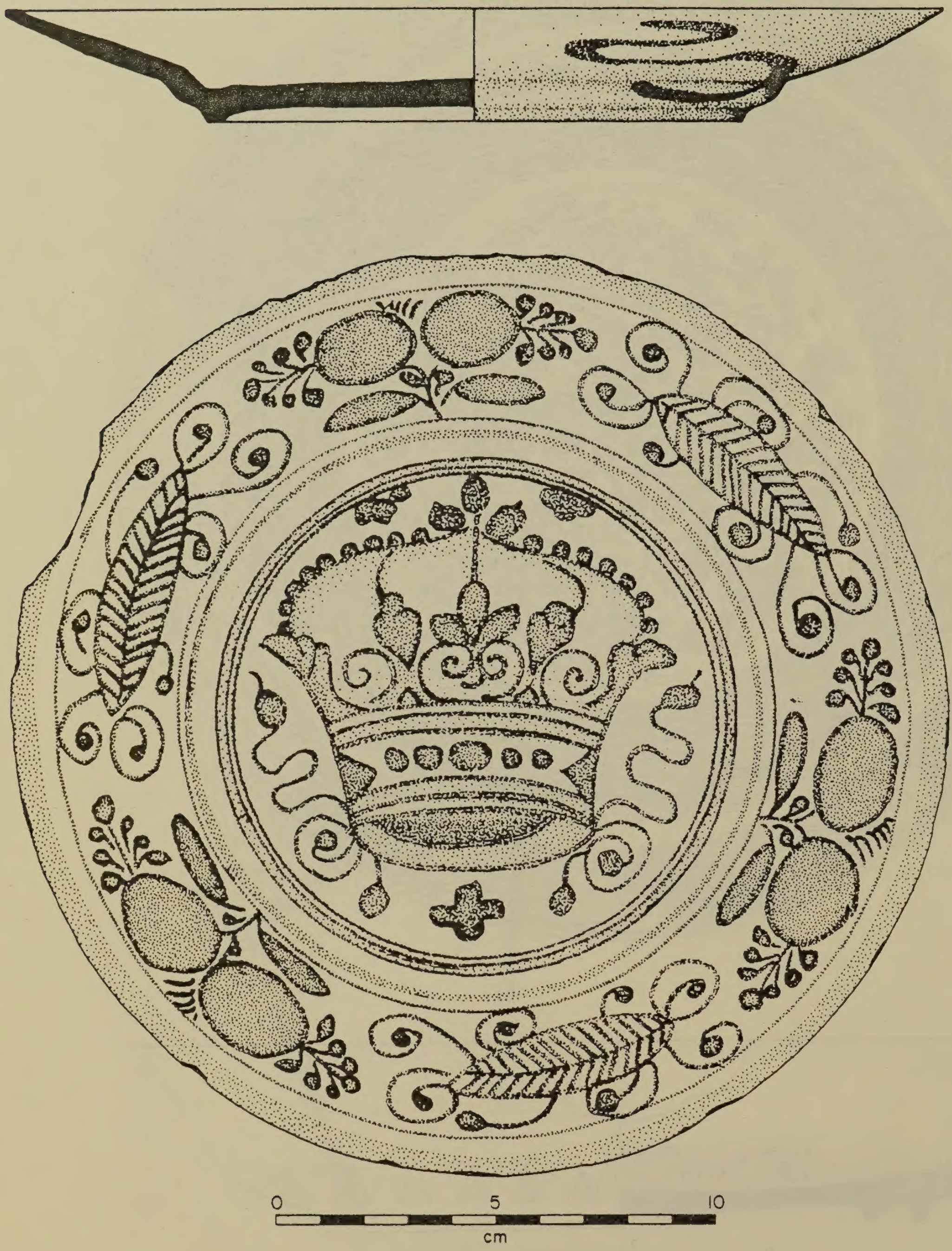

Figure 3. Portuguese blue and white glazed earthenware plate with ‘covered’ crown motif; floral border derived from patterns on Chinese porcelain.

3 m long by 1·5 m wide, and a pile of roughly squared wooden spars. The concretion, almost certainly contains cannon balls and weighing in excess of two tons, is possibly from the shot locker. The exact length of the spars is still unknown as they were not completely uncovered. They are at least 6 m long and approximately 0·20 m square.

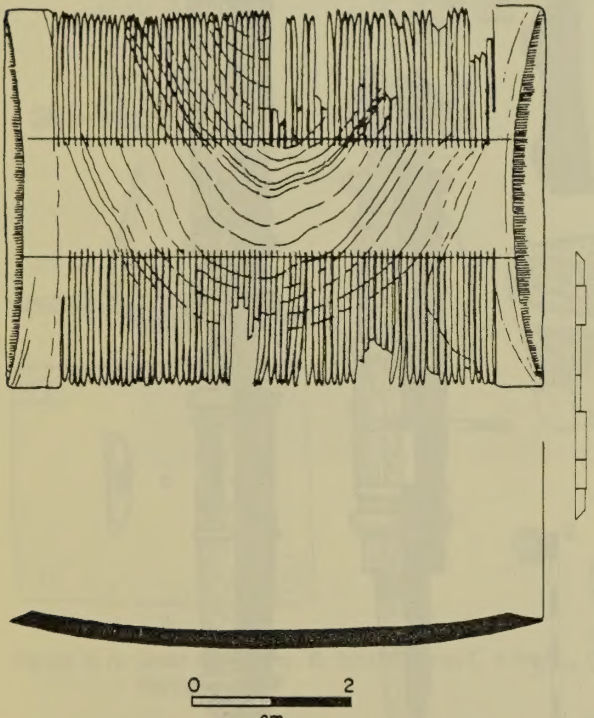

Figure 4. Fine-toothed horn comb.

The excavation of the area around 25 H continued to yield a surprising mixture of items—a Chinese porcelain plate (Fig. 2) very close to a Portuguese glazed ware plate with central crown motif (Fig. 3), a broken but fine earthenware pitcher and a fine-toothed comb made of horn (Fig. 4). A very decayed roll of reed matting (Fig. 5) was also found mixed with fragmentary shelving, partitioning and studs. Crushed against the transverse partition were the remains of a small barrel with a stave length of approximately 0·75 m (Fig. 6). This differs considerably from barrel staves found earlier aft of the mast step which were 1·29 m long. Lying near the small barrel on the ceiling was a wooden caulking hammer (Fig. 7) and unused caulking. This lends further

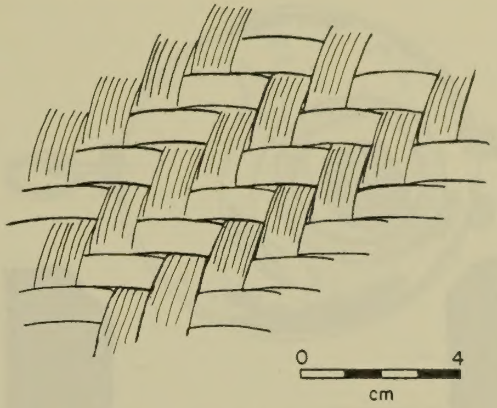

Figure 5. Pattern of matting weave.

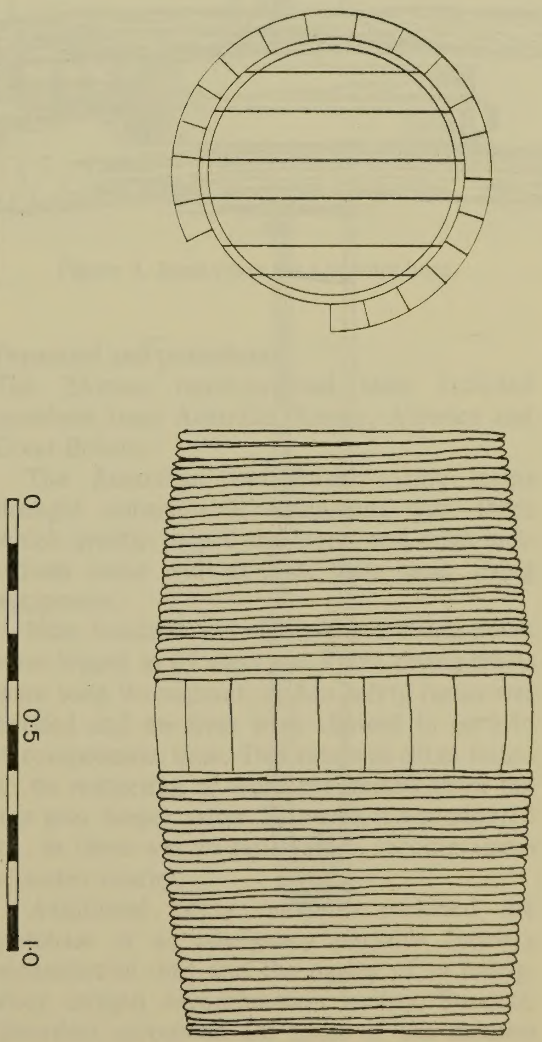

Figure 6. Reconstruction of wooden barrel, 1·32 × 0·7 m.

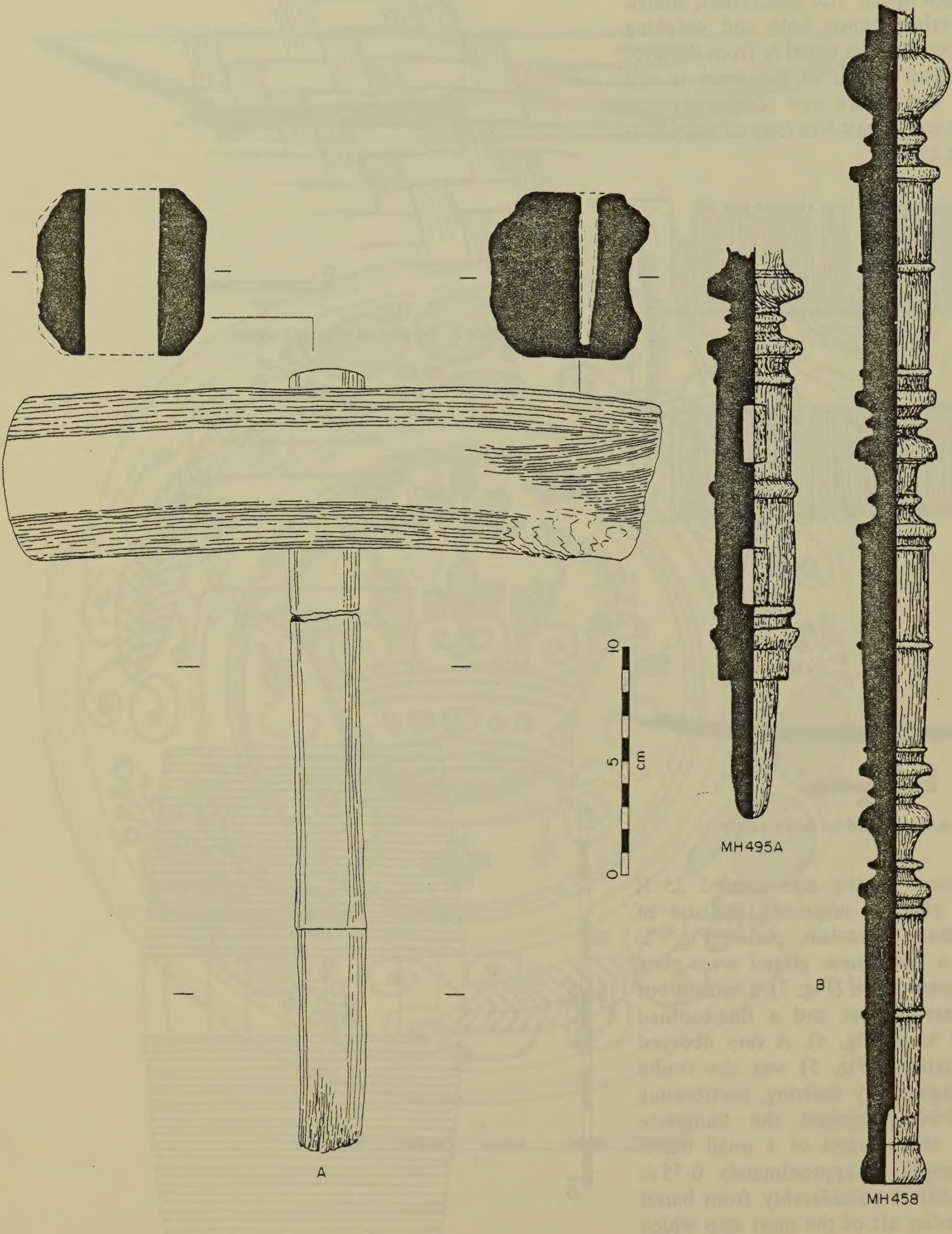
10
5
0
cm
MH495A
MH458
A
B

Figure 7. A. Wooden caulking hammer; B. pieces of lathe-turned wooden furniture.

weight to the theory that the area formed part of a general or bosun s store. Other objects found included pieces of lathe-turned hardwood furniture (Fig. 7), a brass cover for a powder horn (Fig. 9) a brass lock-plate, a brass fitting and a lead fishing weight (Fig. 8).

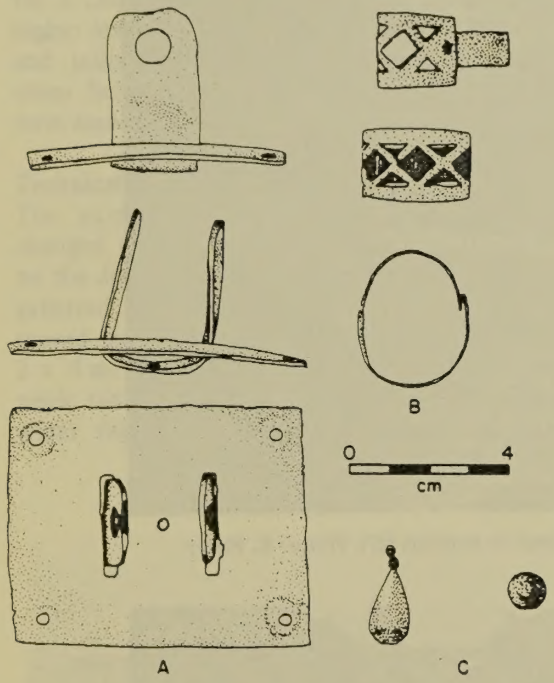

Figure 8. A. Brass lock-plate, B. brass fitting; C. a lead fishing weight.

On the extreme port side, ballast stones, which had spilled out as the ship collapsed were removed to expose a longitudinal wooden partition (Fig. 10). Behind this lay a large mound of sail and rope. Fragments of canvas, brailing lines and cringles can be clearly seen (Fig. 11). It was from within the edge of this mass that the four compasses were previously excavated. In the early stages of the stern excavation a considerable problem was posed by the presence of two large, concreted boxes. These were stuck fast to the hull with other metal pieces of rigging. Using extremely small charges of explosives both boxes were sufficiently loosened to be easily removed to the surface. Damage was minimal and almost certainly less than that which would have been caused by the more conventional method with hammer and chisel.

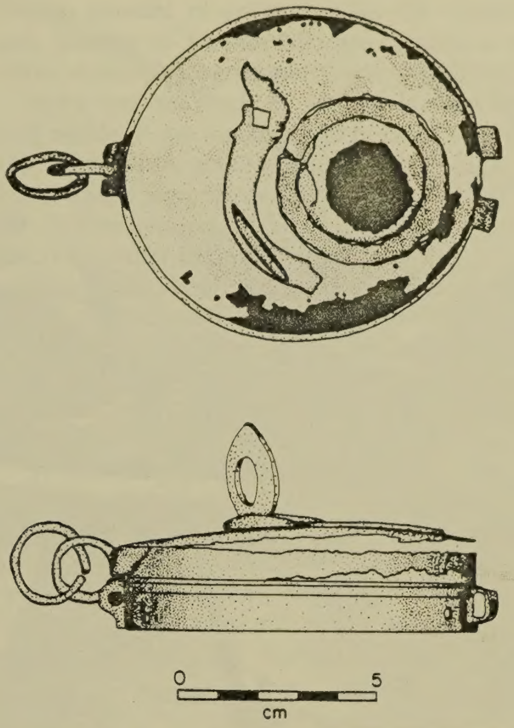

Figure 9. Brass cover for a powder horn.

Personnel and procedure

The 28-man, multi-national team included members from Australia, Kenya, America and Great Britain.

The Australian and British Army teams brought considerable equipment with them which greatly helped the work, and most individuals came with at least their basic diving equipment.

Nine hundred and eighty-seven diving hours were logged in 67 days and RNPL diving tables were used throughout. A 2-m safety factor was applied and no dives were allowed to go into decompression time. This rule was often found to be restricting as work progressed down the site into deeper water. However, it was adhered to, as there was no satisfactory decompression chamber nearby.

Additional safety measures included the purchase of an emergency portable Oxyviva resuscitation unit and the rigging of an emergency oxygen decompression facility. Stomach disorders accounted for most of the sickness incurred, while ear infections, known locally as 'coral ear', accounted for the remainder.

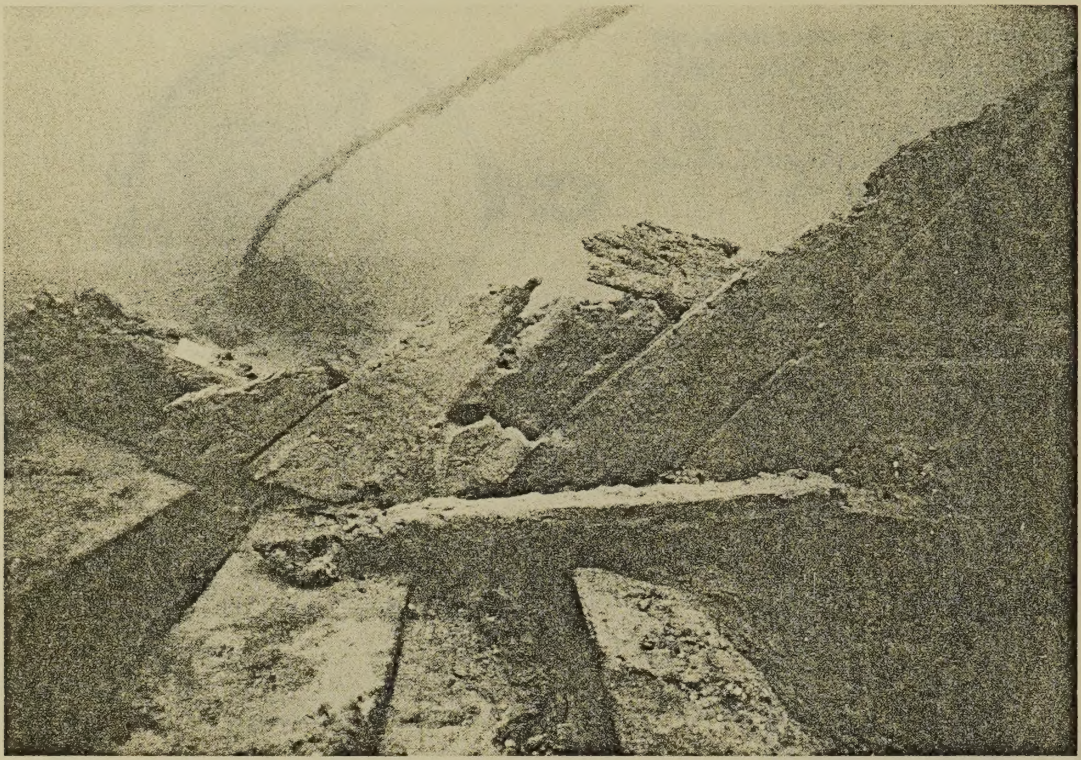

Figure 10. Transverse stern partition with port side hanging knee on extreme left. Photo: R. Piercy.

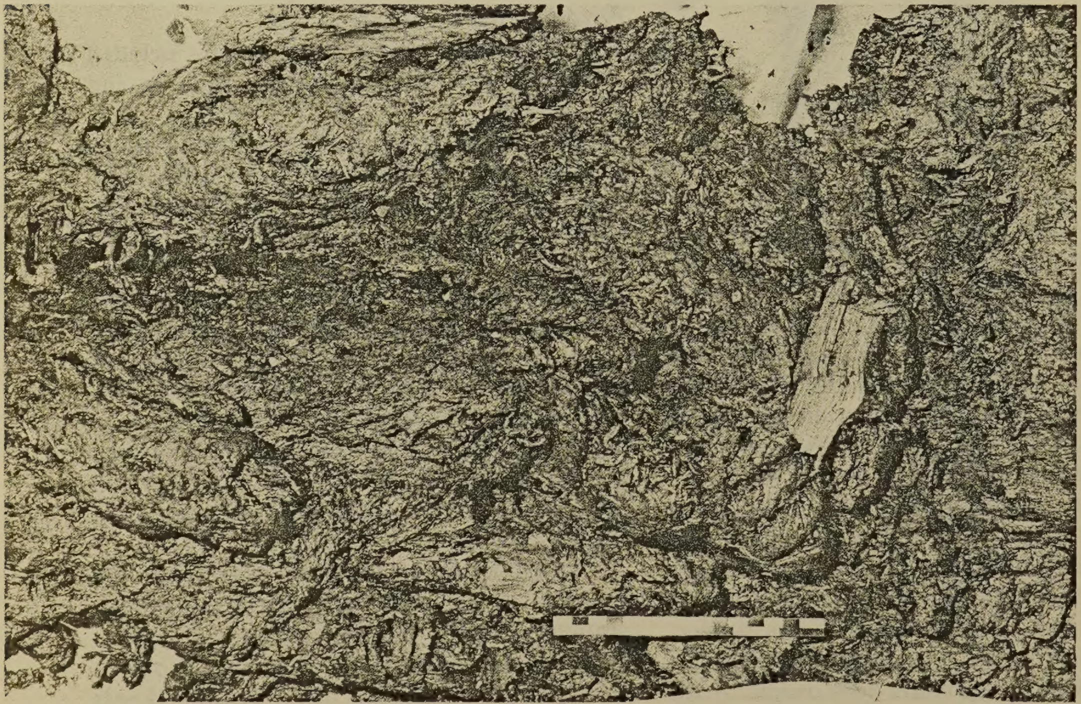

Figure 11. Part of sail found stored in stern area. Photo: Wendy Turner.

A smaller team this season meant that everyone could dive twice a day, providing that the correct 6 hour surface interval was allowed between dives.

By special arrangement it was possible to accommodate everyone in the same house within walking distance of the site. This made for a closely-knit team and a correspondingly higher level of organization. Short slide lectures and talks by members stimulated interest in other fields and projects with which the staff were associated.

Technical

The excavation's diving base remained unchanged (Fig. 12). A few minor modifications on the deck were made as a result of experience gathered in the first season. The office was moved into the centre section and enlarged to 2 x 4 m. This allowed incorporation of another work table and gave a dry area to the underwater film making team. It also afforded a certain amount of protection for the considerable number of 15 mm Nikonos cameras in use when stereo-photogrammetry was in progress.

More use was made of surface demand lines and within a few weeks it was possible to maintain four divers simultaneously. Six locally recruited staff were trained by the Kenya Navy to act as hose tenders. This released valuable manhours for other excavation jobs.

Comfort on board was considerably increased by the erection of a corrugated asbestos wall aft of the main compressor on the bow. As the noise was deflected away from the deck, conversation was possible even when standing within a few feet of the compressor.

A new diving ladder with two sets of steps and an underwater platform was mounted amidships and proved to be of great assistance, especially when artefacts of a delicate or awkward nature were being handed to the surface. The old ladder was utilized as a companionway for boarding the *Sea-Cow;* the name given

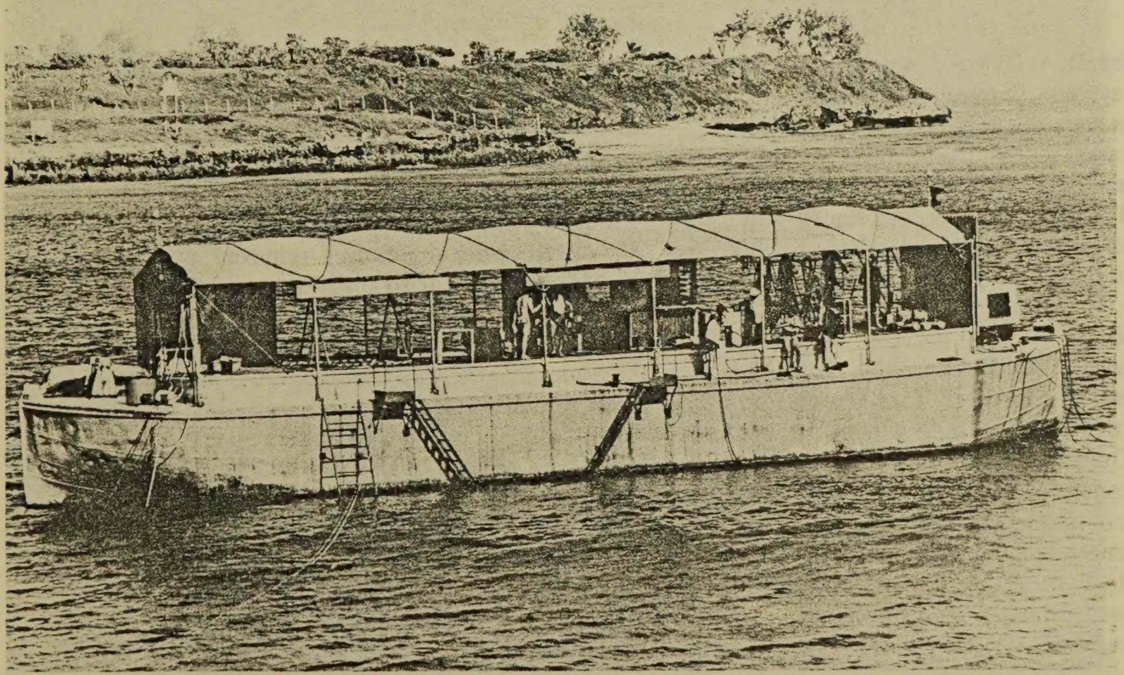

Figure 12. The excavation barge anchored over the site. Compressor and sound proofing are on extreme right with diving area next to it. In the centre is the office and on the left the clear area for artefact storing and recording. Photo: C. Ingelman-Sundberg.

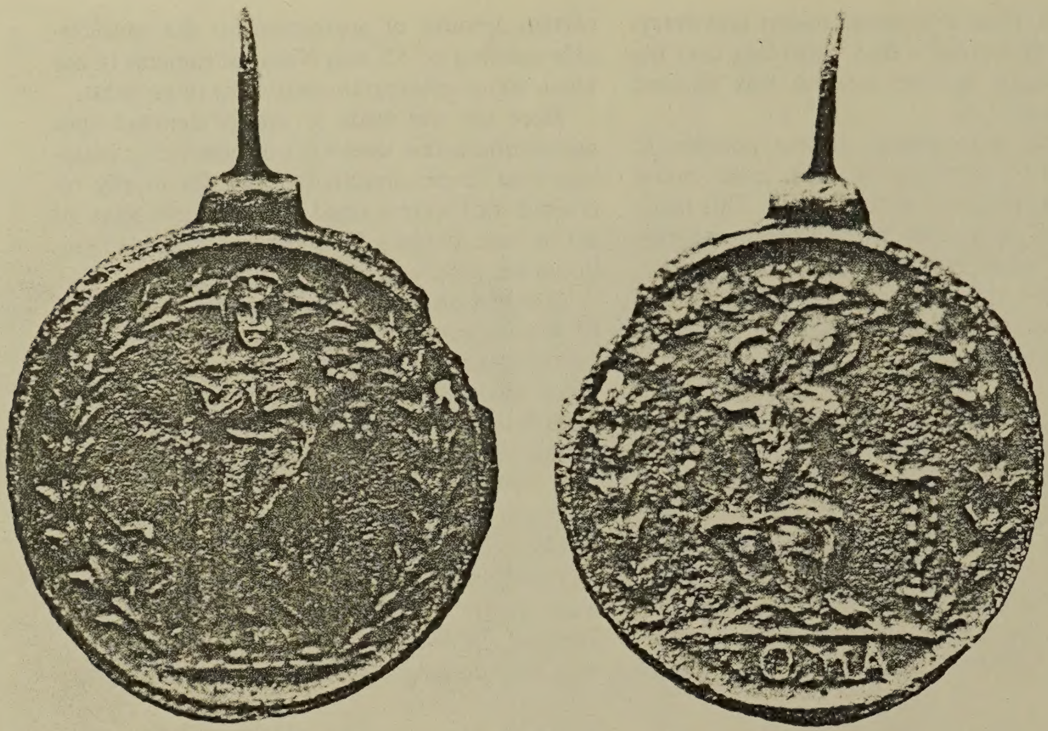

Figure 13. Religious medallion with ROMA in exergue, diam. 0·017 m. A medallion with similar legend was found in the excavations in Fort Jesus.

to a 6-barrel raft which worked on an endless pulley system between the barge and shore. This was capable of carrying six passengers.

The area at the stern, made vacant by the re-located office was devoted entirely to first aid and storage objects. Artefacts were fully recorded before being sent ashore to the conservation laboratory in the Fort.

Conclusion

The records indicate that the *Santo Antonio da Tanna* was lost off Fort Jesus in approximately the position of the wreck being excavated. The material found in the hull and the ship's construction does indicate a ship of European origin. Indeed it would be too co-incidental for another ship fitting the *Santo António da Tanna's* description to be in more or less the same position.

The recovery of the glazed plate with the crown, and a Christian medallion (Fig. 13), possibly of Santo António lends weight to this conclusion.

In reviewing the past two season's work it is fair to say that the ship was obviously abandoned and allowed to decay in her present position. The relatively small quantity of material recovered, indicates that almost everything of value was taken off. Records state that the Portuguese themselves removed much of the armament prior to abandoning the frigate.

It is also known that shortly after the fall of the Fort, in 1698 the Arabs salvaged a considerable number of the cannon on board. They were mounted in defensive positions on the island against Portuguese counter-attack.

Acknowledgments

The writer gratefully acknowledges the extremely hard work put in by members of the excavation team and the generous help of all the sponsors who made the project possible. Particular thanks should go to Hamo Sassoon for his untiring efforts in co-ordinating and bringing the whole project to its present state. He left Kenya in June and will be greatly

missed. The drawings are by Caroline Sassoon, Gay Piercy, Myra Stanbury, and David Williams. The site plan was drawn from a photomosaic by Jeremy Green and Pat Baker.

Appendix 1

The survey procedure

This section of the report deals with the surveying techniques used to record the structure of the ship uncovered during the second season (Fig. 13). The techniques were based on the experience of the first season and were devised to meet the rather peculiar conditions of the site.

Since it was required to produce detailed plans of a three-dimensional form, both photogrammetry and standard measurement recordings were used. However, the nature of the site produced limitations in the application of both techniques. Poor visibility, except at high spring tides, precluded the constant use of photographic recording. Likewise, poor visibility and tidal currents made tape measurements unreliable and it was difficult to establish an accurate base line for recording purposes. In addition, problems were encountered due to the peculiar orientation of the ship, which lay on a steep slope, inclined 20° down towards the bow and with a tilt of 54° to port.

The keelson was twisted along its exposed length, and there was evidence at the scarf joint that the stern section, including the keelson, had moved in relationship to the bow.

These distortions have been extremely difficult to sort out because of the unusual orientation and the lack of a useful datum, such as the base of the keel to work from.

The overall shape of the structure was recorded by measuring profiles at 1 m intervals across the hull of the ship at right angles to the keelson. A stereo-photogrammetric survey over the whole of the inside of the ship was made so that detailed information of the internal structure could be recorded. Control points were surveyed so that the photogrammetric survey could be related to the profiles and incorporated in the overall plans. Detailed measurements were also made of the keelson, which served as the base-line for the survey.

Profile recording

The profiles were measured at 1 m intervals

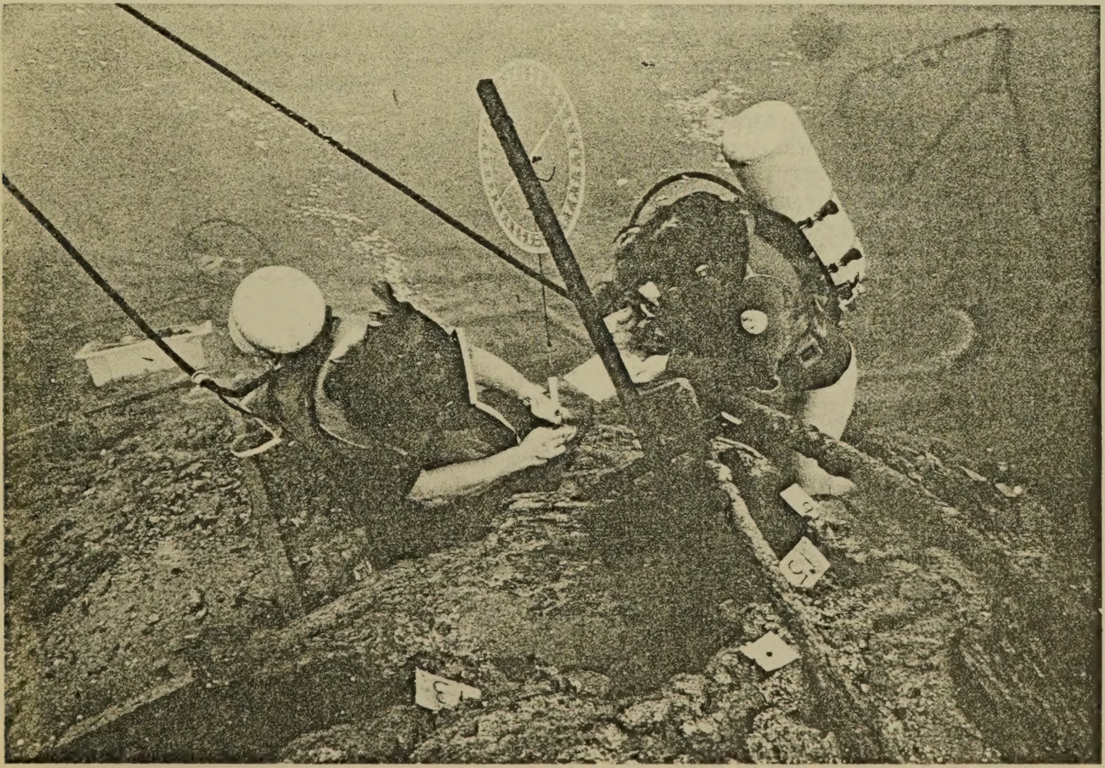

Figure 14. Measuring profiles, stereo-photogrammetry frame in background. Photo: R. Piercy.

along the keelson using a circular 0·75 m diameter, 360° protractor, graduated in half degrees and mounted on a bar 1 m long (Fig. 14). The bar was clamped to the upper (starboard) side of the keelson so that the plane of the protractor was at right angles to the keelson. A pin mounted at the centre of the protractor acted as a swivel for a 0·5 m length of thin string with a stirrup at the end, through which a 10 m survey tape was threaded. Two operators were required to record profiles. One noted on a rough sketch of the profile the position where measurements were taken and gave each position a number. The tape was doubled through the stirrup and back to the zero point, so that the tape operator recorded twice the distance against the position number. The protractor recorder noted the angle and the true distance against his record number. When the tape operator was ready for a reading to be taken, he gave two pulls on the tape and the protractor operator noted the readings and gave a similar signal when he was finished.

Using this technique it was possible to work in poor visibility (*c.* 1 m) where the two operators were out of sight of each other. The double distance measurement helped to sort out errors and missed readings. A variety of techniques were used to ensure that the tape operator took the readings in a line at right angles to the keelson. One of the quickest and simplest (and therefore the best), was to scribe a line on the timbers, using a 1-m square placed against the keelson. The line was extended across the site using a straight edge. The overall method was fast and reasonably accurate.

In a 61-minute dive, with experience, it was possible to do two 6 m profiles consisting of a total of 80 readings. Using a small hand-calculator (Hewlett Packard 25) the polar co-ordinates were converted to rectangular (or x and y) co-ordinates, which greatly facilitated the plotting of data. The calculations required 0·5 m to be added to the measured distance (to allow for string stirrup) and, provided the angles were recorded consistently, the results when converted to rectangular co-ordinates were plotted on graph paper (Fig. 15). The accuracy of the technique was basically governed by the size of the protractor and was about ± 2%.

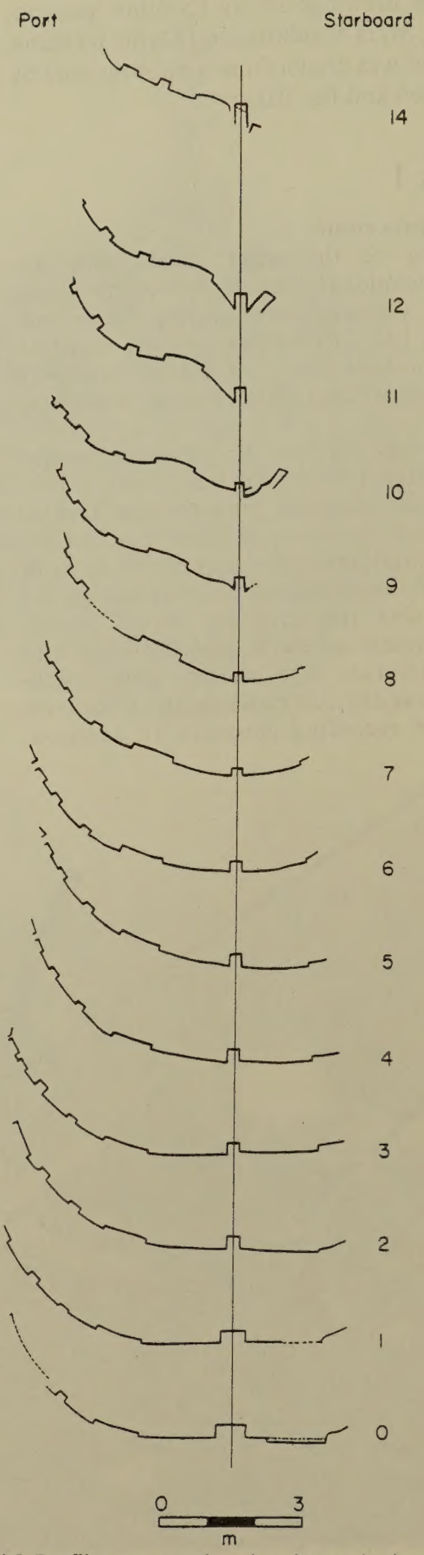

Figure 15. Profiles measured at 1 m intervals along the keelson. Zero is at stern end of socket for mast foot, see plan Fig. 1.

Photographic recording

Two Nikonos III cameras were mounted 0·5 m apart on an aluminium stereo bar. One camera was firmly mounted in a locating bed of hard epoxy resin, whilst the other was mounted in a flexible bed of silicon rubber and was provided with screws to adjust the vertical and horizontal tilt of the camera. On hand, two targets with viewing holes through their centres were mounted 0·5 m apart on a levelled bar at about 5 m from the levelled stereo bar. Using plane mirrors in place of the lenses, the stereo bar was adjusted so that the image of the target in the mirror, on the fixed camera, when viewed through the corresponding target, coincided with the centre of the optical axis of the fixed camera. Subsequently, the adjustable camera was adjusted so that the corresponding target coincided with the optical axis. In this way both cameras were accurately aligned so that their optical axes were parallel. The stereo bar was then mounted on the photo-tower to be used underwater, this tower consisted of a 2 m square base graduated in 0·1 m intervals, with stays supporting a 2 m bar, 1·88 m vertically above the base (Fig. 16). The bar was constructed so that, when the stereo bar was fitted to it, the optical axes of the camera lenses lay on the centre line of the base square, equidistant about the centre of the grid. Fine adjustments were made using the mirror system to set the photographic plane of the stereo bar parallel to the plane of the grid frame. With this arrangement, there was a photographic overlay over the whole of the 2 m grid frame, the 15 mm lens giving in fact 20·8 mm focal length in water. Ping-pong balls on 0·5 m of white string were attached to the mid-points of each side of the grid frame. As these floated upright in water, it was possible to determine the orientation of the camera plane to the true vertical. The orientation of each pair of stereo photographs could be determined for reference purposes by extending the line of the strings to the nadir point. The line joining the nadir point to the principal point of the photograph, gave the direction of the true vertical, and the ratio of the length of this line to the effective focal length of the photograph gave the tangent of the angle of the true vertical to the camera axis. Photographic exposures were made at 1 m intervals, and the runs were made at 1 m intervals, thus ensuring good end- and side-lap between the stereo pairs. Using two plastic buckets for buoyancy the photo-tower could be moved around quite easily by one person, although for accurate positioning two people

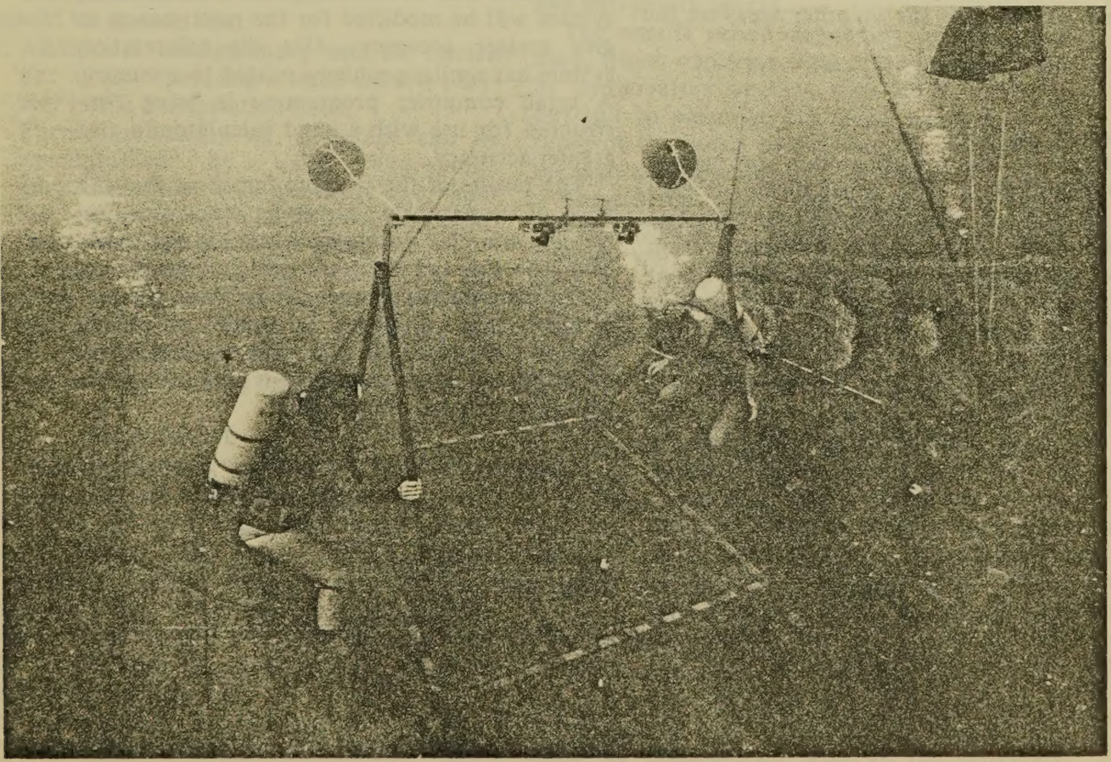

Figure 16. Stereo-photogrammetry frame in position over interior of hull. Photo: R. Piercy

were required. Great care had to be taken not to stir up sediment, particularly as most photography was carried out at high water when there was no current. Considerable variation in the quality of photographs was noted over the three high-water spring tide periods when this photogrammetric coverage was carried out. This was due partially to the variation in the quantity of suspended matter in the water and also due to the light level caused by the effects of cloud and the time of day. In many cases the coverage was a compromise, particularly as the best visibility conditions, corresponding to the highest tides, fell just after dawn or just before sunset when the light levels were too low for good results. Under normal circumstances, using FP4 rated at 400 ASA and given twice normal development in D76, exposures ranged from f2·8 at 1/30 to f5·6 at 1/60.

Considerable planning was required in preparation for the high-water spring tide periods when this type of photogrammetry was possible. The timbers had to be cleaned of any silt, sand and other material that collected as a natural result of the muddy water and stray discharge from the airlifts. If possible, airlifting was terminated about one hour before highwater, and the timbers were then brushed to remove the fine silt. No other diving was carried out during the photographic runs to prevent disturbance of the fine silt in other areas on the site.

Trilateration survey

The survey of the control points was carried out by trilateration. The upper starboard edge of the keelson was selected as the base line. The control consisted of tags driven into the keelson and port and starboard extremities of the site at 2 m intervals. A 2 m rod was clamped against, and at right angles to the upper edge of the keelson opposite each of the keelson controls. Measurements were made to the three nearest controls on both the port and starboard sides of the site, from the base of the rod and at the keelson, and the mark 2 m above the keelson. Thus, if the rod was at the 4 m keelson mark, 12 measurements were made to port 2, 4 and 6 marks and starboard 2, 4 and 6 marks from both points. The offsets of the control marks on the keelson to the rod were measured, and the angle of the rod to the true vertical was measured using a carpenter's level. With this information, it was possible to calculate the three-dimensional co-ordinates of all the control points.

Conclusions

This report essentially deals with the recording techniques. It is hoped to complete the recording of the fore-part of the ship during the next season and publish the results subsequently. However, as the author is at present working on this material, some comment on the results is included. Results indicate that the photogrammetric technique gives the greatest information and flexibility. Thus, at a low level of accuracy, with little effort, a photomosaic of the whole site, using one of the stereo-pairs, has been made. This gives good visual information, but suffers from distortions caused by forcing a three-dimensional curved surface into a two-dimensional plane. With a simple parallax bar and mirror stereoscope, spot heights can be determined and profiles made. With a radial plotter, orthographic plans of the stereo-pairs can be made, but preliminary results have not been encouraging. A programme using a stereotope and other stereoscopic plotting instruments is being carried out to determine the most effective method of producing plans. Using the orientation of the true vertical for each stereo pair, each plan may be reduced to common vertical and horizontal planes.

True profile data has shown that at large distances the errors create problems in plotting the vertical and horizontal plans. The recording system will be modified for the next season to give greater accuracy. Also the trilateration system has similar problems related to accuracy. A small computer programme is being constructed for use with a hand calculator to give greater accuracy.

The results of the work so far, show that the area of underwater surveying has some extremely complex problems. Little has been published on this type of work, which is surprising, considering its importance. Some form of compromise exists between accuracy and time; possibly the use of photography and hand measurement is the answer. It is hoped that this work may resolve the problem.

Jeremy Green
Curator Maritime Archaeology Department
Western Australian Museum

Appendix 2

Progress report on evaluating the Thessaloniki Process

Principles

Research carried out during 1975–76 at the

Wood Technology Laboratories at Thessaloniki University in Greece was aimed at a process for the treatment of water-logged wood which would accomplish the following:

1. The prevention of micro-biological attack during the critical period when wood is removed from, e.g. a sunken wreck, and stored prior to the final conservation.
2. Mechanical reinforcing of the structure of the treated wood.
3. Prevention of shrinkage of the wood when it dries.
4. Permanently preserving and conserving wood for exhibition in museums or institutions.

The principles of the Thessaloniki Process consist briefly of the following:

1. The wood is immersed in a concentrated solution of sodium borate, containing a smaller amount of sodium silicate and a water-soluble organic polymer.
2. The wood is superficially dried to its fibre saturation point of about 24–28% moisture.
3. The wood is transferred to another container and immersed in a concentrated $Ba(OH)_2$ solution which will cause precipitation of Ba-borate and Ba-silicate inside the wood.

It should be stressed that:

1. Additional strengthening can be carried out by incorporating a water-soluble polymer in the precipitation bath.
2. Further reduction of shrinkage can be accomplished by using hydrophilic materials which will penetrate the cellulose structure of wood and prevent cellulose-to-cellulose hydrogen bonding.

The main part of the work carried out at the Chemistry Department of Nairobi University has consequently consisted of evaluating the use of *reinforcing polymers* and *hydrophilic materials of anti-shrinking properties.*

Experimental part

In Thessaloniki water-logged woods of different origins and different age were investigated. (Wood of Viking origin, ships from Scandinavia and the Mediterranean area, and very old wood from glaciers which had been water-logged for 100 000 years.)

The wood investigated at Nairobi all came from the Mombasa wreck.

The Thessaloniki Process was used as originally developed but with the addition of water-soluble and alcohol-soluble polymers as reinforcing agents, and several organic compounds as anti-shrink agents.

The following materials were evaluated:

Reinforcing agents
Polyvinyl alcohols
Polyvinyl butyrates
Polyvinyl acetate-maleate
Polyvinyl acetate-crotonate
Polymethacrylates
Hydroxyethyl cellulose
Methyl cellulose
Sodium resinates
Sodium alginates

Anti-shrink agents
Ethyl glycol
Butyl glycol
Ethyl diglycol
Butyl diglycol
Diethylene glycol
Monopropylene glycol
Propane triol (glycerol)
Diethanolamine
Isopropanolamine.

A series of experiments were carried out with different woods from the Mombasa wreck and using various combinations of the reinforcing and anti-shrink agents.

The results varied depending on the wood used, which confirms what often is pointed out by conservators working with wood, that it is difficult to prescribe one single method for all types of wood due to the extreme variations of the state of degradation of water-logged wood.

Some of the wood from the Mombasa wreck was in a remarkably good condition while other samples were degraded to a very soft consistency. We know from before from our work at Thessaloniki that the reasonably good wood may have a specific weight of 0·6–0·9 while the very soft wood may have a specific weight of only 0·1. While it is possible to develop methods that can treat both types of wood, it is extremely difficult to treat a wood which is comprised of both types in one piece.

Another serious problem with the wood from the Mombasa wreck is that sufficient micro-biological activities had taken place to produce gelatinized wood which clogs up the pores of the wood making impregnation very difficult or impossible. (This requires confirmation by scanning electron microscope studies.)

The results were in general that some of the wood samples (in particular the softwoods) could be impregnated with all the polymers used while other samples were impervious to impregnation. As a matter of fact, some of the woods were so difficult to impregnate that even the sodium borate and the sodium silicate did not penetrate the wood to the core. Such planks would look stable after treatment on the surface, but would later suffer internal collapse.

While many of the reinforcing agents diffused only with difficulty into some of the 'problem' woods, all the anti-shrink agents would diffuse into the wood without any difficulty due to the small molecules of these compounds. However, polyethylene glycol with much larger molecules (e.g. grade 4000) would not during the available time (4–10 weeks) diffuse into the core of planks of even 0·03 x 0·15 m cross-section.

The results in short, showed that while some of the wood could be treated with the Thessaloniki Process (containing reinforcing and anti-shrink agents), others could not be treated sucessfully within a reasonably short time.

However, if sufficient time was available, it seems certain that even the 'problem' wood could be treated.

Present state of investigation

It appears that the use of precipitated Ba-borates must be complimented with polymer reinforcing agents and hydrophilic anti-shrink agents. While the chemicals used in the original Thessaloniki Process have quite small molecules, and therefore penetrate rapidly into any wood, the larger molecules of the reinforcing agents may take much longer time to diffuse into the interior of the wood.

However, the situation is more favourable than in the treatment of wood with polyethylene glycol. Polyethylene glycol of grades 2000 and higher have much larger molecules than the water-soluble polymers we have tried, and consequently will require much longer time for complete penetration than the materials we have used.

The situation is nevertheless quite complicated especially because of the differences encountered in the different wood samples.

There are contradictory and conflicting requirements which must be fulfilled to treat widely different wood samples. When the wood is highly degraded with a density of below 0·3, it is absolutely necessary to use reinforcing polymers of some sort. However if the cell walls of the wood fibres are degraded to this extent, anti-shrink agents have little effect.

An anti-shrink agent works by keeping the cell walls in a permanently swollen state (as the wood originally was when immersed in water), but when the amount of the cellulose and lignins in the cell wall has been reduced below a certain critical value, no anti-shrink agent can keep the wood permanently swollen so as to retain its original shape and size.

The bulking effect and reinforcing value of precipitated Ba-borate and silicate will under such conditions be inefficient, and the anti-shrink agent will be of little value. Under such conditions, a water-soluble polymer must be used.

The situation can therefore be summarized as follows:

1. In woods with low to medium degradation, the Thessaloniki Process with anti-shrink agents can successfully be used. Polymer reinforcing agents are then of little use and may, in fact, prolong the time for treatment.
2. In highly degraded wood, anti-shrink agents are of little use while polymer reinforcing agents must be used to prevent collapse of the wood.

Present and future work

The basic principles of the Thessaloniki Process have proved to be sound, but both reinforcing and anti-shrink agents must be used simultaneously.

While we have solved the problem of the anti-shrink agent (to be reported elsewhere), we are still evaluating the various polymer reinforcing agents.

The difficulties regarding reinforcing agents are mainly caused by their large molecular sizes which do not allow a rapid penetration.

The present work is therefore aimed at developing a water-soluble polymer of very low molecular weight but with sufficient mechanical strength when dry.

Another alternative is also being investigated, which consists of using polymers in organic solvents after the wood has first been dehydrated with alcohol or acetone.

Both methods are being evaluated concurrently and will be reported later.

Special comments

It has often been stated that the most difficult of all problems of conservation of archaeological artefacts is the treatment of waterlogged wood. This is not only due to the inherent difficulties of conserving a highly deteriorated material, but also due to the very large variations encountered between wood samples from the same excavation.

The wood breaks down quite differently as the result of varying environmental conditions, not only from one excavation to another, but even within the same piece of wood whether this is a large beam or a small artefact.

Much more research is therefore required to study the properties of water-logged wood and methods for their treatments. Close teamwork between wood chemists, conservators and archaeologists is required to solve all the problems.

Karl Borgin
Adjunct Professor, Institute of Nautical Archaeology,
and Lecturer in Chemistry,
Nairobi University

Appendix 3

Conservation of the finds

Conservation—a kitchen science is an apt term for facilities at Fort Jesus Museum where the laboratory is in the converted prison kitchens (Leigh, 1973). The laboratory is headed by Mr Hamo Sassoon with one part-time and two full-time assistants. The conservation of finds from the Mombasa wreck came under my supervision for two months of the 1977–78 season.

Most chemicals and reagents are available in Mombasa; sodium carbonate is manufactured in Kenya. Specific conservation chemicals such as benzotriazole, polyvinyl acetate, microcrystalline wax and Baven ASAK leather dressing had to be brought from Britain. The constantly high humidity of Mombasa precluded the use of hygroscopic materials such as grades of PEG below molecular weight 4000 or neatsfoot oil and the high coastal temperature made solvents with high boiling points such as toluene of xylene preferable to acetone which evaporated too quickly. Rubber gloves and small tools such as glass bristle brushes and plaster tools were difficult to obtain.

States of preservation

The wreck lies in the sea at the foot of Fort Jesus buried in a marine sediment of fine black and grey clays, broken shells and other debris. Iron has corroded to very hard concretions cementing together artefacts and voids which formed as iron migrated from the objects into the concretion.

Copper alloys formed an even black patina which protected the surface from further attack. Lead alloys were also well preserved, but with an irregular brown or grey corrosion layer covering pits of white or grey crystalline material[1].

Heterotrophic bacterial activity in the sediments had been inhibited so that organic material—wood, bone, leather and rope has been well preserved. Exposed pieces of wood, however, have suffered extensively from shipworm attack, and in one instance from secondary occupation of the Teredo galleries by a young octopus. Hydrogen sulphide, a metabolic product of anaerobic sulphur bacteria caused the blackening of lead-glazed ware and the thin shell lights of the lantern. Otherwise the sediments have restricted mechanical damage sufficiently to allow the survival, unbroken, of the floral vases and glass case bottle.

Conservation methods

After removal of finds from the environment which has preserved them for 300 years it is important to prevent deterioration as objects adapt to new conditions.

All finds were stored in tap water until their conservation treatments could start. Wood was stored in a 2% solution of boric acid and sodium borate (ratio 7 : 3 parts weight) (Oddy, 1975) (Barkman & Frantzen, 1972). Other organic material was stored in thymol solutions, covered to prevent access by mosquitoes. Ironwork and concretions were kept in a 5% sodium carbonate solution (Oddy, 1975) and copper alloys in 1% benzotriazole in distilled water.

Metals

Metals were cleaned mechanically and stabilized chemically. Electrolytic reduction was only used when this was not practicable as reduction can cause considerable weakening of an object which is badly corroded and does not have a sound metal core. In extreme cases it can result in severe pitting or even holes and cause a loss of the original shape of the artefact. Reduction must also be followed by thorough washing to ensure complete removal of the electrolyte which will otherwise continue to corrode the object (Hamilton, 1973).

Bronze religious medallion. After the loose black corrosion layer had been removed the medallion (Fig. 12) was soaked under vacuum in a 3% solution of benzotriazole in industrial methylated spirits (Masden, 1967). It was lacquered with 'Incralac,' an acrylic polymer containing benzotriazole, manufactured by ICI.

Silver-plated buckle. In many places the thin silver coating had worn away exposing the bronze beneath. The layer of black silver sulphide was brushed off and the buckle treated with benzotriazole.

Ironwork. Selected pieces were experimentally treated by soaking in a 0·02% solution of alcoholic lithium hydroxide (Brestle, 1974). The results will be evaluated next season.

Lead and pewter. Unless exposed to organic vapours lead and its alloys are resistant to corrosion and usually need only mechanical cleaning and a coating of microcrystalline wax (Oddy, 1978). Several case-bottle tops had a brown corrosion layer which was difficult to remove. They were reduced electrolytically for 30 minutes in a 2% solution of sodium hydroxide with steel mesh anodes. A current density of 200 mA DC per square decimetre at 5 V gave the most satisfactory results. The case bottle lids were then thoroughly washed in changes of distilled water until the pH was constant, dried through industrial methylated spirits and waxed.

Organic material

Leather. Items of no more than two layers were preserved by soaking for a 1½ h wash after each bath. They were dewatered in four successive acetone baths of 1 h each and dried between absorbent tissue and two plates of glass for at least 24 h. A leather dressing was then brushed on made up of 1 g Dowicide I fungicide, 50 g anhydrous lanolin and 20 g Bawon ASAK-ABP, a leather lubricant based on a copolymer of a polyhydric alcohol and a partial ester of an unsaturated hydrocarbon and made up to 1 litre with 1'1'1' trichloroethane (Rector, 1974). The preserved leather was flexible and a natural brown in colour. Thicker pieces, like the heel stacks were soaked in PEG 4000 (Carbowax) at 60°C with a gradual increase in concentration from 0% to 100% v/v over 14 days. Enough water was allowed to evaporate to accommodate each daily addition of PEG.

Rope. After pieces of the rigging had been cleaned with 2% oxalic acid which softened the mud and lightened the colour of the rope, they were soaked in PEG 4000 and treated as the leather heel stacks. This method was found preferable to solvent drying which left the rope shrivelled and distorted.

Bone or horn double-edged comb (Fig. 3). Mud was removed by brushing with a detergent solution. The comb was dried through 50% industrial methylated spirits and water, 100% IMS and two baths of xylene.

Shell lantern lights. A hydrogen peroxide 5 volume soaking overnight removed the black stains on the lantern lights. They were desalinated in changes of distilled water and dried through baths of 50 : 50 water/IMS and 100% IMS.

Wood. The spindles and other small pieces were preserved by the acetone-resin method (McKerrell, 1972). The compass box was soaked for 10 months in a solution of PEG 4000 (Carbowax) at 60°C while the concentration of the wax increased by evaporation of the water (Werner, 1968).

It is hoped that the remainder of the wood, including the complement of barrel staves, can be preserved by the Thessaloniki Process which is being developed by Professor Karl Borgin at the University of Nairobi.

Inorganic finds

Ceramics. Surface concretions were removed mechanically or with formic acid (immediately after excavation) before they had time to harden. Desalination commenced as soon as sherds reached the laboratory, firstly by changes of tapwater and then distilled water until the soaking solutions gave negative reactions with acidic silver nitrate. Blackened lead glazes were bleached with 5 volume hydrogen peroxide to reveal their pink and blue enamelling. Care had to be taken to prevent the dislodging of weakened glazes by the oxygen bubbles evolved during the bleaching process. As a precaution they were secured by soaking in a PVA 5 solution in toluene and acetone between the glaze and the fabric of the ceramic. Any resin on the surface had to be removed as it would have prevented access of the peroxide to the glaze. Iron stains which remained after bleaching were removed with local applications of 10% oxalic acid which was rinsed off with water (Olive & Pearson, 1975). The ceramic was then allowed to dry.

Glass and the case bottle. The condition of glass varied from occasional surface pitting to severe exfoliation. After desalination pieces were dried through two changes of IMS.

The case bottle, although almost complete was in a very weakened state. The glass had begun to exfoliate, was badly cracked and was held together only by the compacted clay inside. To remove this clay would have caused the disintegration of the bottle. It was decided to trim down the mud to leave a 5 mm lining, excavating through a hole in one side where the glass had been lost during burial. The clay lining could then be reinforced with netting and resin.

To support the glass while the mud was being removed the bottle was faced with netting held in place with polyvinyl acetate, but because of the fragile condition of the glass the facing could only be applied while the bottle was still supported in water. The level of the water was reduced to expose the upper face only which was dried thoroughly by swabbing with IMS and acetone. The surface was consolidated with PVA and a synthetic net facing applied. The facing was secure enough to withstand soaking in water while the other sides were faced. The mud was then removed to leave a thin layer on the inner side of the bottle. At this stage the bottle could be taken out of the water and dried, after which a netting support was stuck to the inside layer of mud with Paraloid B72, an acrylic resin which is not soluble in IMS[2]. The PVA and net outer facing could be safely removed with this solvent with no risk of weakening the lining. Finally the surfaces were cleaned and given a final consolidating coat of PVA.

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Senior Conservation Officer
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Notes

[1] Facilities for analysis of these corrosion products were unfortunately not available but comparison with material from the lead anchor stock found at Aberdaron, north Wales (Boon, G. C., 1977, *IJNA* 6: 239–42) suggests the crystalline material is cerussite or phosgenite.

[2] A similar consolidant could be made by dissolving 'Perspex' or 'Plexiglas' shavings in acetone.

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AMERICAN INSTITUTE OF NAUTICAL ARCHAEOLOGY
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Report No. 4

An 11th century shipwreck at Serçe Liman, Turkey

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Sections on the hull and anchors were written by van Doorninck; the other sections by Bass.

Between 1 June and 10 September, 1977, the Institute of Nautical Archaeology began the excavation of a shipwreck inside Serçe Liman, a natural harbour on the southern Turkish coast opposite Rhodes (Fig. 1). The wreck lies about 75 m from the north-east shore inside the harbour mouth at a depth of *c.* 33 m. It was located during the institute's 1973 survey (Bass, 1974: 337–38; 1975: 34 figs 10–12), and was chosen for excavation not only because of its apparent cargo of glass, but because it seemed to be of around the 12th century AD, a critical period for the study of wooden hull evolution.

Methods

We constructed a semi-permanent camp of three concrete-block buildings on the shore nearest the wreck, for living, drafting, photography, conservation, and equipment repair. Such facilities proved necessary for efficient work in frequent strong winds.

A 50 ft (15 m) wooden barge, used at Yassi Ada and Sheytan Deresi since 1961, was anchored directly over the site throughout the campaign, and the underwater telephone booth also used at those sites was placed on the seabed before full-scale diving commenced. Next we covered the estimated extent of the site with a rigid metal grid of 2 m squares; the grid was lowered in welded sections, 2 m wide and 4–6 m long, and these were wired together on the fairly even bottom. Two-man excavation teams were assigned, when possible, to the same individual or adjoining squares to insure continuity of excavation in those squares. Mapping was accomplished by a sequence of photomosaics taken by a Nikonos camera with a 15 mm lens; controlled seabed measurements, by triangulation, showed the resultant plan to be highly accurate (Fig. 2).

We removed overburden with a pair of PVC airlifts, 0·10 m in diameter, but as usual much sand was simply swept downslope by hand. Glass sherds were collected from 0·50 m squares into labelled polyethylene bags and carried to the barge by hand; on deck we rinsed them before they were sent to the workhouse for sorting and cataloguing. Each bag was then pierced with small holes and moved through a series of week-long baths in concrete basins containing progressively less saline mixtures, from $\frac{2}{3}$ sea water to $\frac{1}{3}$ sea water to fresh water. Before being packed into boxes for slow drying, sherds were given a final rinse in fresh water and placed into fresh bags, also pierced with small holes. Pottery was soaked for a few days in fresh water before being allowed to dry slowly (usually in pierced plastic bags); as all fresh water for the camp was brought by boat from Marmaris, four hours away, it was not possible to change the water as frequently as we might have wished, and past experience has shown that pottery, once dry, suffers badly from later soaking.

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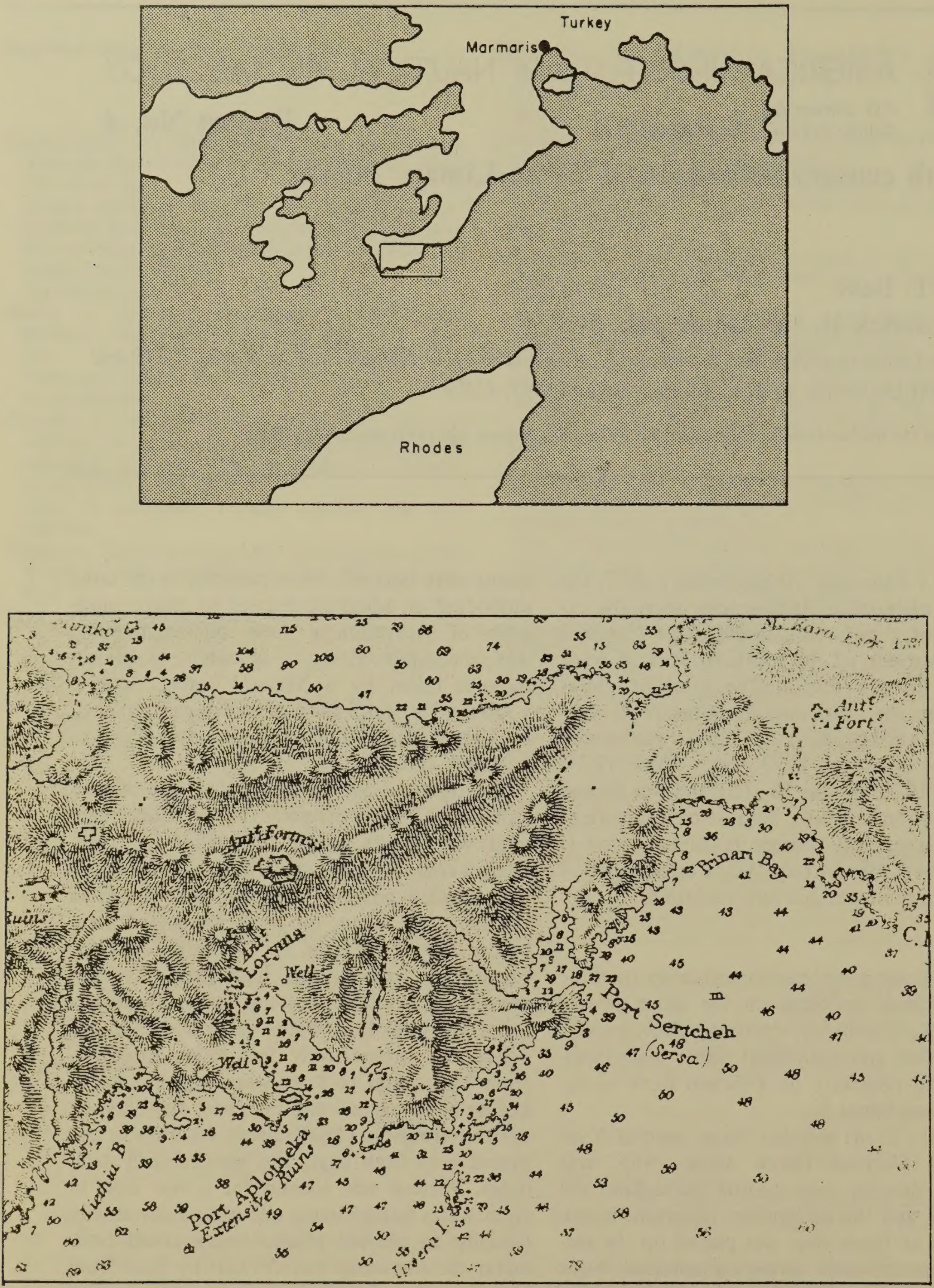
Turkey
Marmaris
Rhodes
Antᵗ Fort
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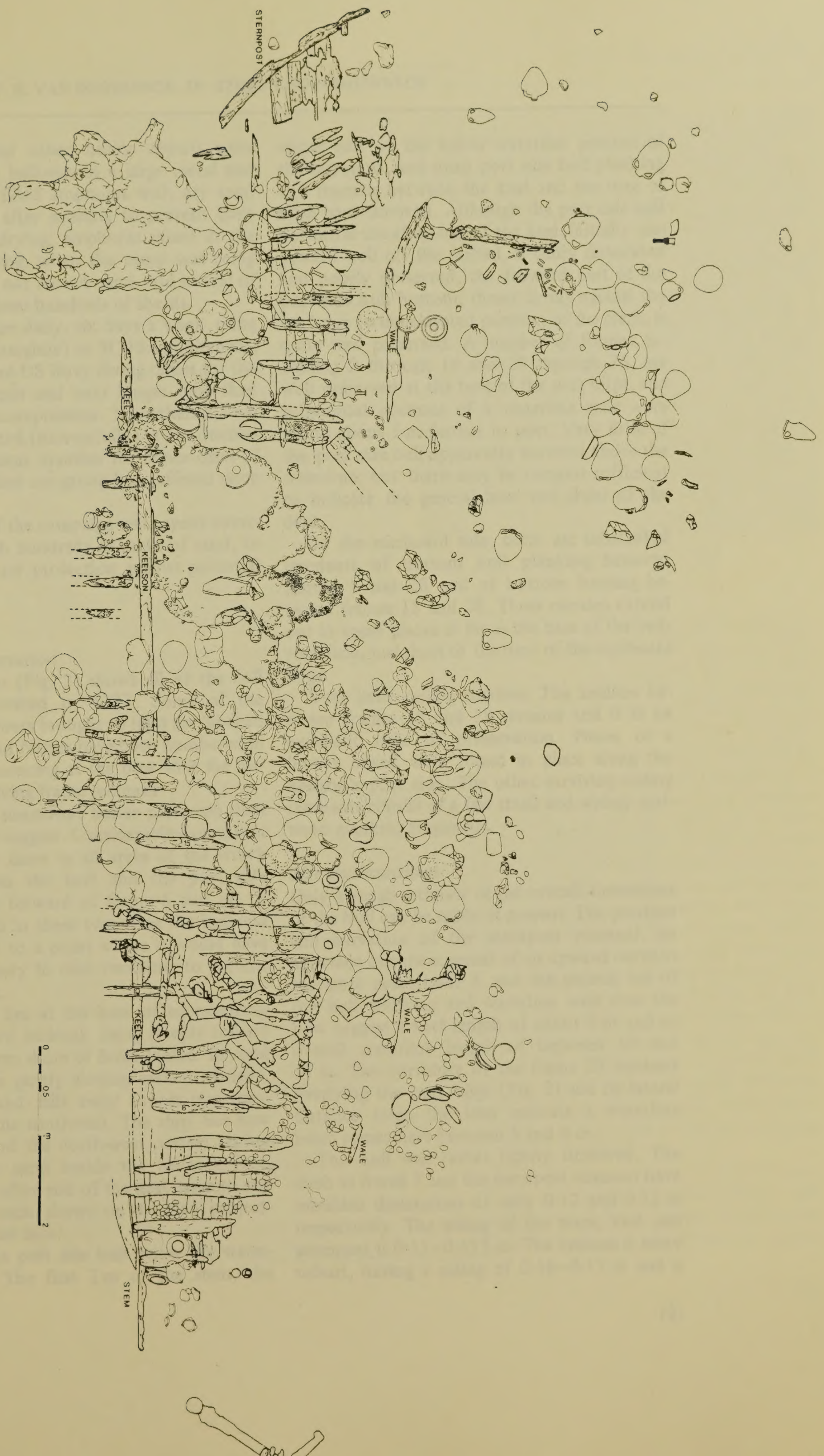
Well
Prinari Bay
Port Sertcheh
(Sersa)
Port Aploþheka
Extensive Ruins
Lithiu B
C.

Figure 1. Map showing position of wreck.


STERNPOST
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WALE
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m
2

Figure 2. Serçe Liman wreck plan, 1977.

Amphoras and other heavy objects were raised by lifting balloons in a large metal and wood tray. We filled amphoras with dry sand for a few days after washing to prevent their cracking while drying; amphoras raised in the last days of diving, when the camp was being dismantled, did not receive sand, and several of these crumbled into hundreds of sherds.

We dived twice daily, six days a week, using either hookah (narghile) or SCUBA equipment, and read standard US Navy diving tables for the next deeper depth *and* next longer time than required for decompression. Nevertheless, two divers were treated (successfully) in our double-lock recompression chamber for minor cases of the bends, the first our group had suffered since 1961.

Final days of the campaign were spent covering the site with hundreds of sacks of sand, to offer some winter protection against potential looting.

The hull

Extent of preservation

The wreck plan (Fig. 2) shows all of the hull remnants uncovered in 1977. Some of the major hull members brought to light are labelled on the plan, and frames have been numbered in sequence commencing at the bow with the forwardmost surviving frame remnant.

The hull is somewhat better preserved than the plan might suggest. Considerable excavation remains to be done in all areas of the wreck except between the keel and the port side waterline wale forward of frame 5 and aft of frame 29. Even in these two areas the hull was not uncovered to a point where it would have become necessary to raise remnants to prevent damage or loss.

The wreck lies at the base of an extensive area of exposed bedrock rising steeply toward the north-eastern shore of Serçe Liman. Beyond the bedrock, a gently sloping seabed of deep, fine-grained sand falls away almost imperceptibly toward the southwest. The ship, her bow pointing toward the north-west, settled on her port bilge on sand beside the bedrock face. However, the after end of the keel came to rest on a mass of rock, shown on the plan, projecting out from the face.

Much of the port side hull below the waterline remains. The first 2 m of the stem, the upper half of the below waterline portion of the sternpost, and most port side hull planking and framing between the keel and the turn of bilge have survived. Although the port side hull bottom at the after end of the keel, initially suspended well off the seabed, is badly dislocated and poorly preserved, the forward part of the port side hull bottom, thrust firmly against the sand due to the elevated position of the stern, is quite well preserved. A number of frames, including 9 through 14 and 29 through 36, are well preserved at the turn of the port bilge, and substantial portions of a waterline wale were found about 1 m farther to port. Very little of the port side hull apparently survived above the waterline, but there may be remains sufficient to indicate the general level and sheer of the deck.

On the starboard side, there are substantial remnants of bottom hull planking between frames 1 and 28 and of bottom framing between frames 13 and 28. These remains extend out in some places as far as the base of the bedrock face, just short of the turn of the starboard bilge.

Very little ceiling survives. The keelson between frames 18 and 28 remains and is in an excellent state of preservation. Pieces of a limber board were found in place along the keelson's port side. The other surviving ceiling remnants consist of a few small and widely scattered planking fragments.

Size and scantlings

Only a rough estimate of the overall dimensions of the hull can be made at present. The position and curvature of the sternpost remnant, an apparent commencement of an upward curve in the stem near frame 5, and the general run of the hull planking and waterline wale into the bow suggest a keel length of about 9 m and an overall waterline length of between 16 and 17 m. The curvature of the frame 29 remnant overlying the port bilge (Fig. 3) and its lateral distance from the keel indicate a waterline beam somewhere between 5 and 6 m.

The hull was rather lightly timbered. The stem at frame 3 and the sternpost remnant have moulded dimensions of only 0·12 and 0·13 m respectively. The siding of the stem, keel and sternpost is 0·11–0·115 m. The keelson is more robust, having a siding of 0·16–0·17 m and a

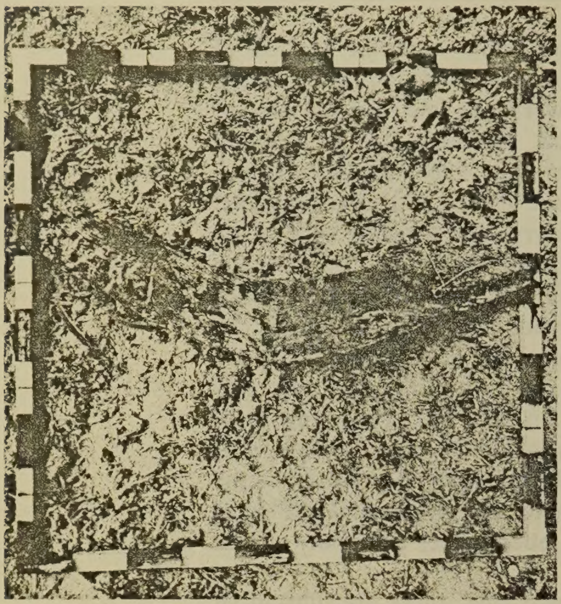

Figure 3. Frame 29 remnant.

moulding of at least 0·15 m. Although some of the frames have sidings of 0·12–0·14 m[1], most frame sections are sided 0·09–0·11 m. Moulded dimensions of frames were not measured, but profile photographs with scale included were taken of the frame 3 and 29 remnants. The photographs yield a height of 0·10 m for frame 3 throughout most of its preserved length and a moulded height of 0·15 m for frame 29 at the turn of the bilge. The average centre-to-centre frame spacing over the length of the keel is *c.* 0·32 m. Grid photographs and a visual inspection of the various remnants of the waterline wale have revealed it to be a relatively light strake with a width of not over 0·16 m and a somewhat lesser thickness. The hull planking other than the garboards has a thickness of only 0·03 m, while the inner edge of the garboards is 0·04 m thick. Most of the planking strakes up through the turn of the bilge attained widths of from 0·18 m to over 0·28 m. Evidence of any relatively heavy ceiling strakes have not yet been found. The surviving remnants of ceiling planking are instead quite thin.

Construction

Not a great deal was learned about the hull's construction during this first season, since we wished to disturb the hull remains as little as possible. Even so, the information that was obtained is of considerable interest.

The framing pattern can be partially discerned. Frames with short floors alternate with frames with long floors. Clear examples of short floors occur on the wreck plan at frames 4, 6, 10 and 12. Futtocks overlap these short floors over the width of two planking strakes about midway between the keel and the turn of the bilge. A laterally driven iron nail fastening floor and futtock was detected at frame 4 (see plan). Futtocks appear to have overlapped long floors at the turn of the bilge. The long floor of frame 3 begins to diminish in height near what is now its outer end in a manner that suggests that it originally terminated just beyond the turn of the bilge. Overlapping sections of framing occur at the bilge turn at frames 33 and 35. These would appear to be frames with long floors.

Both iron and wooden fasteners were employed in the hull's construction. The hull planking beneath the floor remnant of frame 3 was examined and photographed. Three or four small-sized iron nails appear to have been used in most instances in fastening each planking strake to the floor. Treenails were also employed in planking strakes 2–4: a single, centrally located treenail in strakes 2 and 4, and two treenails in strake 3. These treenails were remarkably thin, having diameters of *c.* 0·010–0·013 m. It is not yet known how far nails and treenails penetrated into frames. The floors of frames 1–5 appeared in each case to have been fastened to the keel (stem) by a single, large iron spike. That some floors were bolted to the keel is indicated by the presence of an iron bolt in the keelson at frame 27.

No evidence of mortise-and-tenon joints was detected. Examination of the planking was not extensive nor detailed enough to rule out the employment of joints in the hull's construction, but did make it clear that if there are any joints they must be relatively few in number. One piece of evidence raised particularly strong doubts that joints were used even in the earliest stages of construction. The starboard side of the keel and the inner edge of the starboard garboard were completely uncovered and closely examined over a distance of 1·3 m between frames 2 and 6. The keel side throughout this distance proved to be a plain, vertical face without chamfer or rabbet.[2] Nothing in the way of joints or fasteners of any kind was found. The inner edge of the garboard over the same distance was also devoid of traces of fasteners or of any other features. Clearly the garboards had not in some way been fastened to the keel other than perhaps at very widely-spaced intervals. We did discover, on the other hand, that two well spaced iron nails had been driven through the port garboard close to its inner edge into the floor of frame 3.

The Serçe Liman hull relied more heavily on its framing for strength than did earlier Mediterranean hulls that have been brought to light. It does not have the independently strong shell of Graeco-Roman hulls, nor does it appear to have had as weak a framing pattern at the turn of the bilge and as heavy a system of ceiling strakes as did the Pantano Longarini (Throckmorton, 1973) and 7th century Yassi Ada (van Doorninck, 1972: 140–44) hulls. It remains to be seen, of course, how many of the overlapping sections of framing were joined by lateral fasteners, as was the floor and futtock of frame 4.

Skeletal-building may have been employed in all stages of the hull's construction. The absence of fasteners joining the starboard garboard to the keel between frames 2 and 6 and the manner in which the port garboard was nailed to the floor of frame 3 raise the distinct possibility that the garboards when installed were nailed to floors that had already been erected. Skeletal-building in this part of the hull would have been relatively easy, since the hull bottom had very simple lines. The profile of the floor of frame 3 has revealed that the bottom was fairly flat and without hollows to either side of the keel. Shell-building possibly was employed at the turn of the bilge with its more complex lines. However, the bilge curvature (Fig. 3) appears somewhat too hard to have been produced by the edge-joining of planking as wide and thin as are the bilge strakes.

Clearly the Serçe Liman hull is an important document for the history of wooden hull construction in the Western World. It may shed considerable new light on the origins and early history of modern skeletal-building. The hull, in view of its scantling and construction, is quite well preserved. The hull remnants, if restored would very probably present a clear picture of the hull's original appearance up to the waterline wale. Every effort will therefore be made to conserve these remnants for public display and future study.

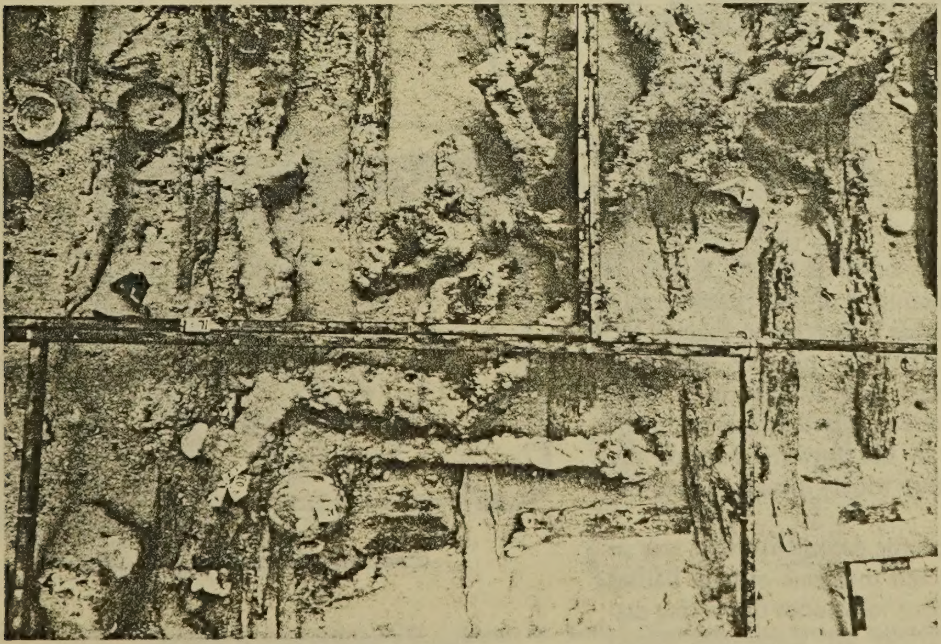

Figure 4. Anchors *in situ* beneath mapping grid.

The anchors

The ship carried iron anchors with removable stocks. Stock remnants have not as yet been brought to light. The anchors have straight arms forming obtuse angles with the shank, and chisel-shaped flukes set at right angles to the arms. Such Y-shaped anchors have been found off the coasts of Cyprus and Sicily and as a general type have been dated to the late Byzantine period (Green, 1973: 171).

Two adjoining piles of anchors were found overlying the port side hull bottom between 2 and 4 m forward of midships. Three anchors were in one pile; two, in the other. It seems clear that these anchors had served as spares and had been stacked on the forward deck midway between the bulwarks. It appears more likely than not that another anchor, lying immediately to port of these anchors, had also been a spare stowed with the others on the deck. A seventh anchor, found at the forward end of the wreck where the bow had been located, probably had been a bower anchor. Another Y-shaped anchor was sighted about 20 m forward of the wreck; it may have been a bower anchor cast before the ship sank.

Direct overall measurements have been taken only of the bow anchor and the uppermost anchor in the pile of three. The latter anchor has been raised but has not yet been drawn or studied in detail. Grid-photographs of the anchors (Fig. 4) indicate that they do not vary greatly in dimensions and possibly were of uniform weight. Shank lengths do not appear to exceed *c.* 1·4 m; the span between flukes, *c.* 1·3 m.

The finds

Distribution

A concentrated area of finds at the bow contained the finest examples of clear glass, largely intact (including those illustrated in Figures 13, 14, 17, 18 and 19); the paucity of other, broken glass *suggests* that it was not a cargo area. More than a dozen glazed terracotta bowls were also found in the forward part of the wreck, but were more widely dispersed than the glass.

Abaft the anchor pile described above was an area of amphoras, and then one of large ballast stones, including four millstones of varying diameters. Slightly farther aft, sometimes mixed with the stone ballast, was a large quantity of cullet—chunks of raw glass destined to be remelted and fashioned into wares. Larger pieces of cullet, up to 0·30 m across, were mostly green, for the manufacture of clear glass, but occasional smaller pieces of blue or amber appeared, as did some containing purple swirls. It is not known if the cullet served as cargo, ballast, or both.

Very heavy concentrations of glass extended from frame 18 to just aft of frame 30 and from the bedrock face to the farthest extent of excavation to port. Almost all of this glass was badly shattered and imbedded in rock-hard concretion. Among the few items other than glass in this area were a bronze bucket (Fig. 5) and several bronze coins, all on the starboard side of the keelson.

Beyond the area of broken glass, both forward and aft, the density of glass sherds fell off quite abruptly. An after group of amphoras did not extend forward of frame 30, save far downslope, and the forward group of amphoras did not extend farther aft than frame 17.

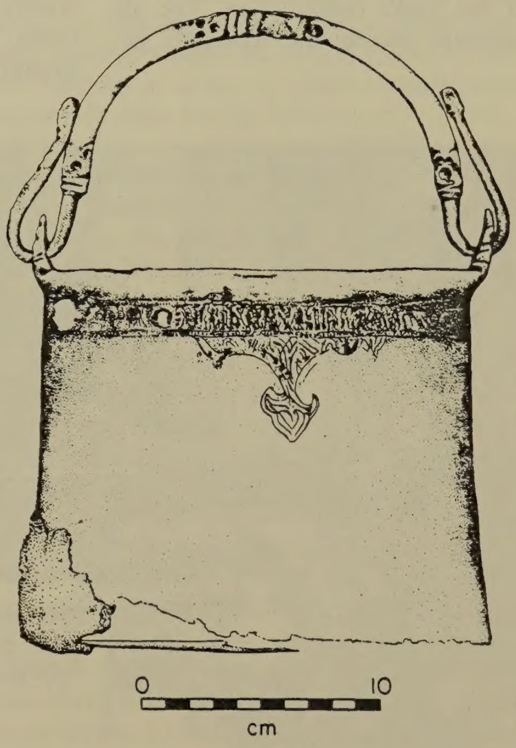

Figure 5. Bronze bucket (GW 55).

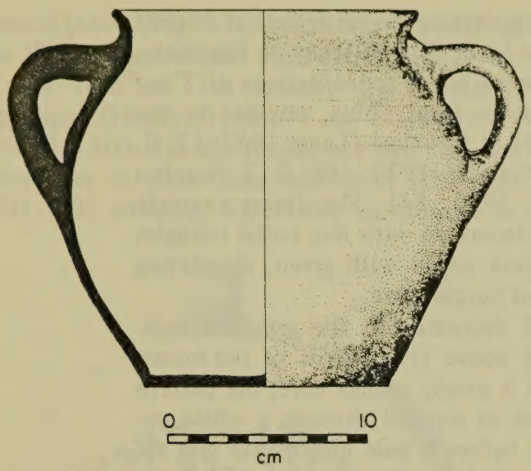

Figure 6. Two-handled terracotta pot (GW 1). Scale 1 : 4.

Living quarters, not yet fully understood, are suggested by finds nearer the stern of the ship. We found there not only terracotta cooking, eating and pantry wares (Fig. 6), but a bowl with bones from a meal (some appeared to be chicken bones, but none have yet been identified positively); at least eight glazed bowls here were of the same types as those in the bow area (Fig. 7). Here, too, were remains of a wooden scabbard and several iron swords, including one (Fig. 8) ending in a bronze hilt with an ornately feathered bird looking back over its shoulder on either side. The area also produced a set of balance-pan weights[3], and numerous lead net weights decorated with cast curvilinear and rectangular patterns.

Glass in this stern area, as in the bow, was often intact, comprising mostly bottles and tumblers, the latter sometimes in stacks. This may have been due to fortune, but it raises the possibility that the huge quantity of broken glass was being transported as glass waste to be remelted along with the cullet.

None of about a dozen coins found so far was as far forward as the cullet, but four Arab glass weights were distributed from the bow to midships to near the stern.

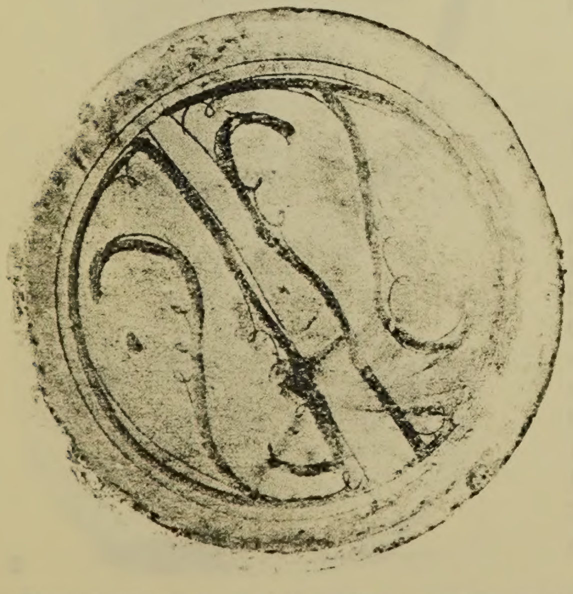

Figure 7. Glazed bowl with *sgraffito* decoration (GW 26). Diameter 0·23 m.

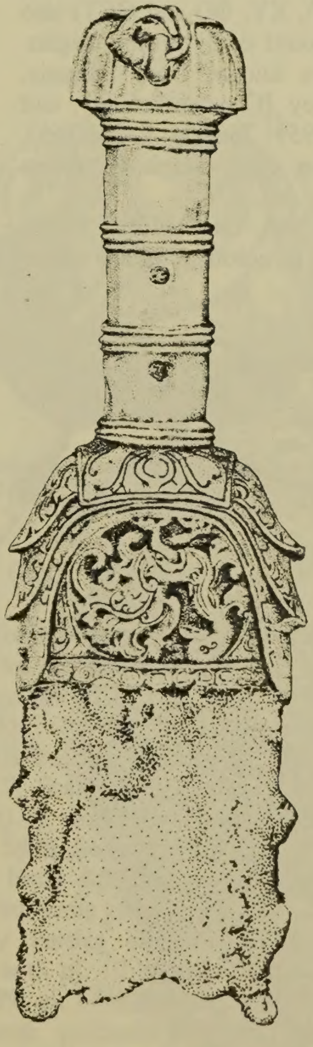

Figure 8. Sword fragment with bronze hilt (GW 56). Preserved length 0·26 m. Scale 1 : 2.

Dating and tentative identification

The wreck can be dated to the early 11th century by Byzantine coins of Basil II (976–1025), and by four glass weights. The latter, used for weighing especially precious items because their exact weights were difficult to alter, have been identified by Michael L. Bates of the American Numismatic Society: three are of the Fatimid caliph al-Hākim bi-Amr Allāh (996–1020) and one of al-Zāhir ‘li-Izāz Dīn Allāh (1020–1035), with the last possibly bearing on its reverse the date 415 AH (AD 1024/5).

Cargo amphoras from the wreck are varied in shape. The most common is piriform and horizontally grooved (Fig. 9); M was inscribed on the shoulders of several before they were fired, but other letters (<Λ, KY, ΦO and ΘCT) also appear, leaving little doubt of Byzantine origins. Similar amphoras are known from Bulgaria, Russia, Greece, Turkey [Constantinople], and Rumania (Cangova, 1959: 250, fig. 5, and 261).

Pottery other than cargo amphoras seems mostly Islamic.

Two one-handled jugs, one reddish brown and the other cream in colour, contain decorative straining devices (*gargoulettes*) of Islamic character; the latter (Fig. 10) may be Egyptian.

Several glazed bowls are imitations of T’ang dynasty imports from China, popular in the Moslem world at this time (Lane, 1947: 12; G. Hudson in Richards, 1970: 160; G. T. Scanlon in Richards, 1970: 84). The finest example (Fig. 11) is decorated with five radial triangles of yellow glaze edged with green, alternating with stripes of purple glaze.

One bowl decorated in the *sgraffito* technique, noted above (Fig. 7), is of red-brown pottery with a nearly orange core; the pattern was scratched or scraped through a white underglaze slip before a pale green glaze was applied to the interior surface. Another (Fig. 12) is coated with a light yellow-green glaze.

Most or all of the intact glass seems also Islamic in origin, as shown by the following selected examples. Unless otherwise noted, the glass is clear; it appears dark in some photographs because silt inside, probably hardened by alkali released through decomposition of the glass, was impossible to remove safely in camp.

A yellow-green globular vase with inverted

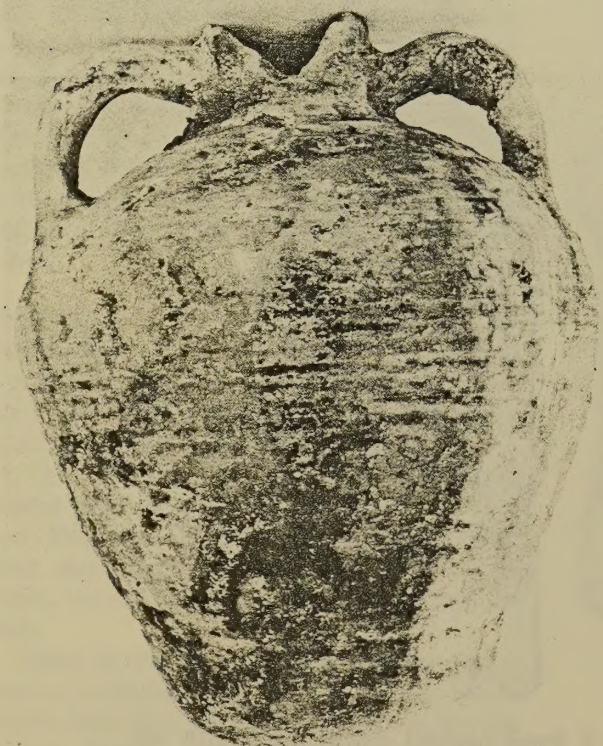

Figure 9. Amphora GW 36. Height 0·41 m.

conical neck (Fig. 13c) resembles a bottle in the Victoria and Albert Museum thought to be of the 10th or 11th century and 'certainly Egyptian' (Honey, 1946: 44 no. c. 29–1932, with pl. 13H); it is also similar to a form known from Iran in both glass and silver (Dimand, 1941: 201 with fig. 6); cf. also an example in the Louvre (Pope & Ackerman VI, 1939: pl. 1442 B).

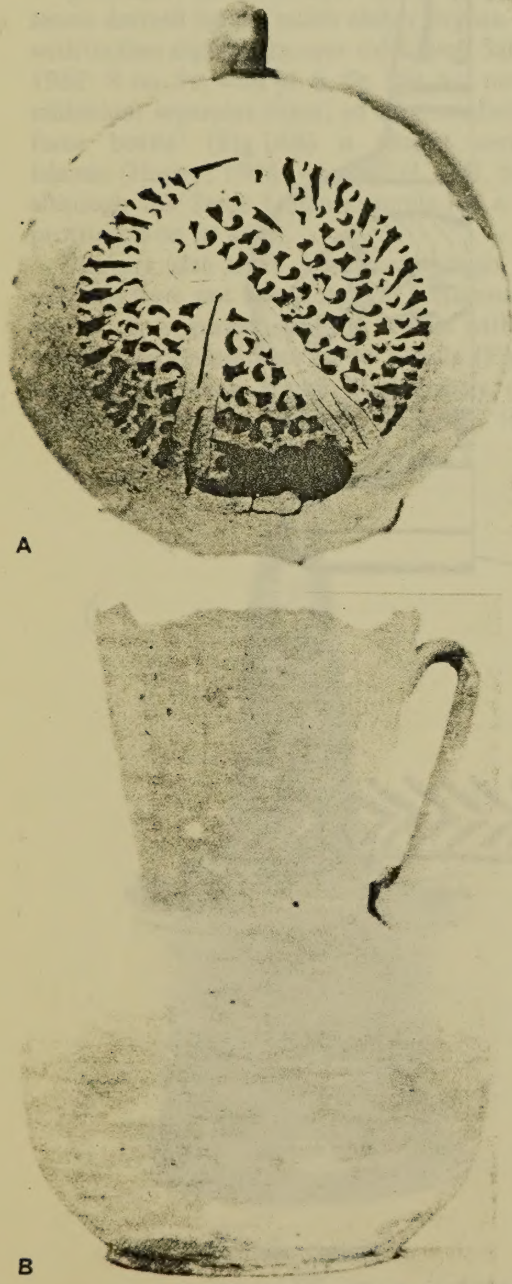

Figure 10. Cream coloured jug (GW 33), ~~with decorative gargoulette~~. Height 0·175 m.

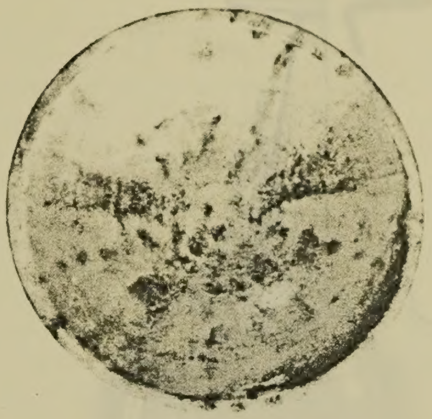

Figure 11. Glazed terracotta bowl (GW 24). Diameter 0·23 m.

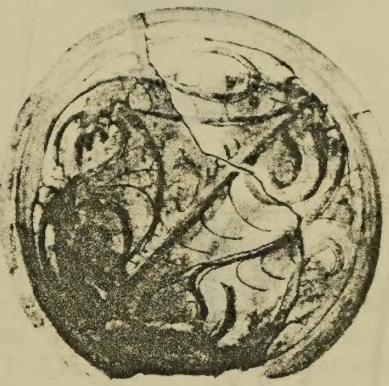

Figure 12. Glazed terracotta bowl (GW 28). Diameter 0·24 m.

Another bottle shape (Fig. 13A) is nearly duplicated by an engraved Persian example dated to about the 9th or 10th century (Corning Museum, 1957: 269 no. 548); cf. also a bottle from a 10th-century context at Fustat (Old Cairo) (G. T. Scanlon in Richards, 1970: 84 with pl. IXa). A more elaborate example of the same form from Serçe Liman, engraved with lions on its body and facets on its neck (Fig. 13B), is of the same general shape as a cut-glass 10th-century Persian bottle (Buckley, 1939: 242 no. 79 with pl. 10; see also Pope & Ackerman VI, 1939: pl. 1442A).

Bottles with pinched, hour-glass bodies at Serçe Liman are usually simply decorated with bands or faceted necks, but one example (Fig.

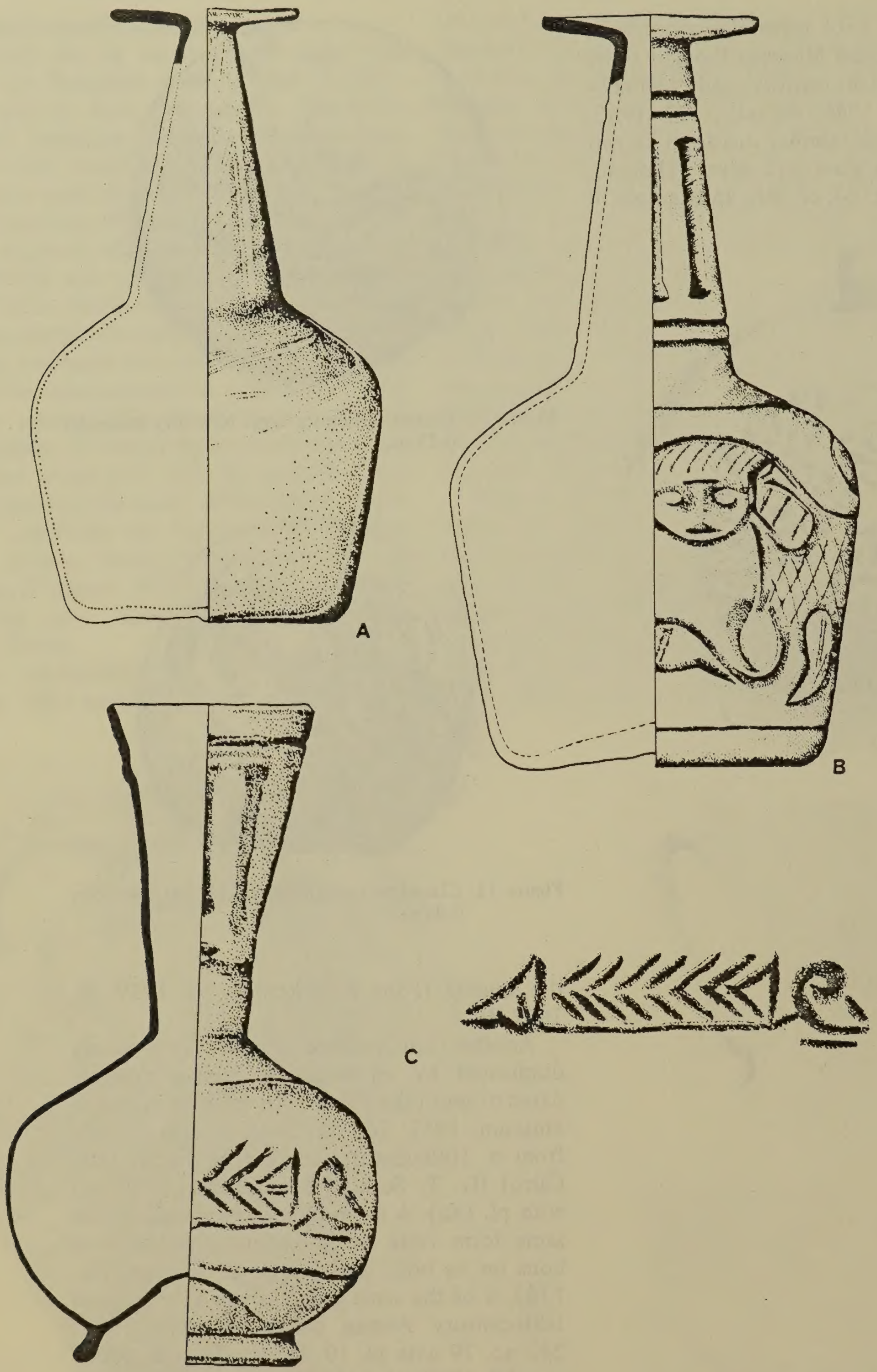

Figure 13. A. Glass bottle GW 64. B. Glass bottle (GW 65) engraved with lions. C. Glass bottle GW 57. Scale 1 : 2.

14) is elaborately engraved, its neck and the rim of its shoulder cut with patterns similar to those on a 9th- or 10th-century Islamic bottle (Corning Museum, 1957: 270 no. 555).

A series of delicate, globular bottles with extremely slender necks (Fig. 15) also have Persian parallels (Lamm, 1935: pl. 3B).

A smaller, less attractive bottle (Fig. 16A) seems derived from a much earlier Roman type, with its four slightly concave sides (von Saldern, 1962: 8 no. 9c, with pl. 6, fig. 10), but nearly a millenium separates them; an even smaller 'perfume bottle' (Fig.16B) is almost certainly Islamic (Honey, 1946: 41, esp. pl. 13B, centre, although the Serçe Liman example has a small protrusion on its base).

Pitchers also seem Islamic, although exact parallels have not been found in preliminary research. An engraved, piriform pitcher with beak mouth and thumbpiece on its handle (Fig. 17) is from the same 'family' as slightly earlier Egyptian examples (Lamm, 1930: pl. 56 nos 3–4; Pinder-Wilson & Scanlon, 1973: 25 no. 19, with figs 30–32; Scanlon in Richards, 1970: pl. VIIb); the shape is possibly descended from still earlier Sassanian pitchers (Corning Museum, 1957: 237 no. 466); a fragment with a fluted body is similar to fragments from Samarra (Lamm, 1928: 43 fig. 28 nos 157a and 157).

A pale green, globular pitcher with inverted conical neck and thumbpiece on its handle (Fig. 18) is of a general Islamic form known both in glassware (Lamm, 1930: pl. 5 no. 8, Syrian, 10th century) and metal (Féhérvari, 1976: 30 and pl. 3b no. 8, Iranian 9th–10th century).

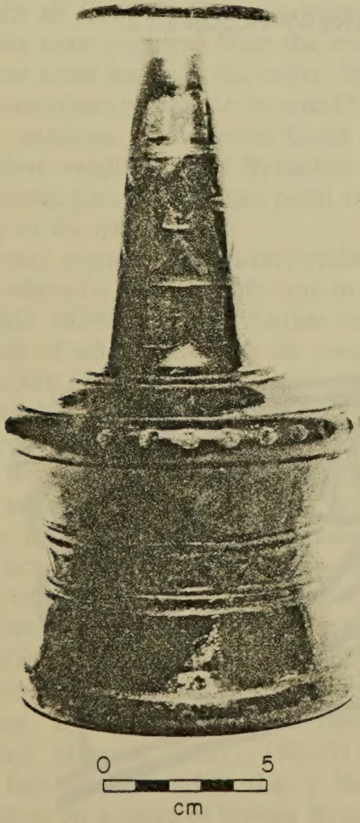

Figure 14. Engraved glass bottle GW 62. Height c. 0·26 m.

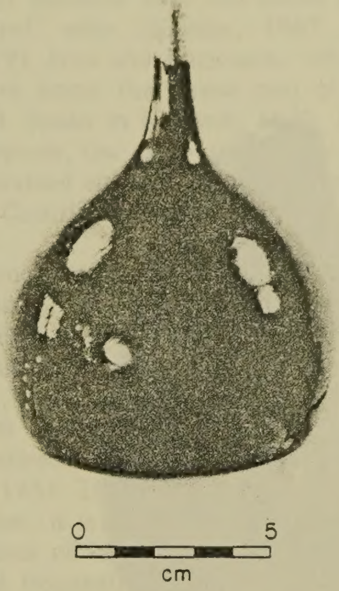

Figure 15. Glass bottle GW 68. Height c. 0·14 m.

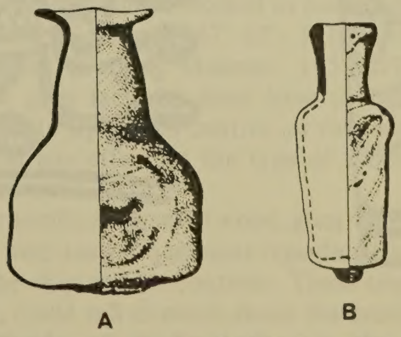

Figure 16. A. Glass bottle GW 73. B. Perfume bottle GW 74. Scale 1 : 2.

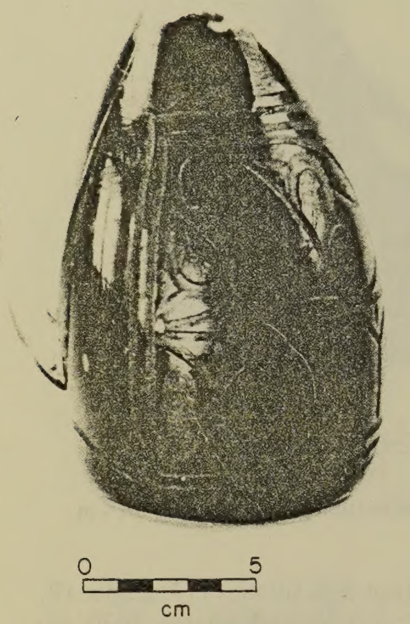

Figure 17. Glass pitcher GW 93. Height without handle 0.18 m.

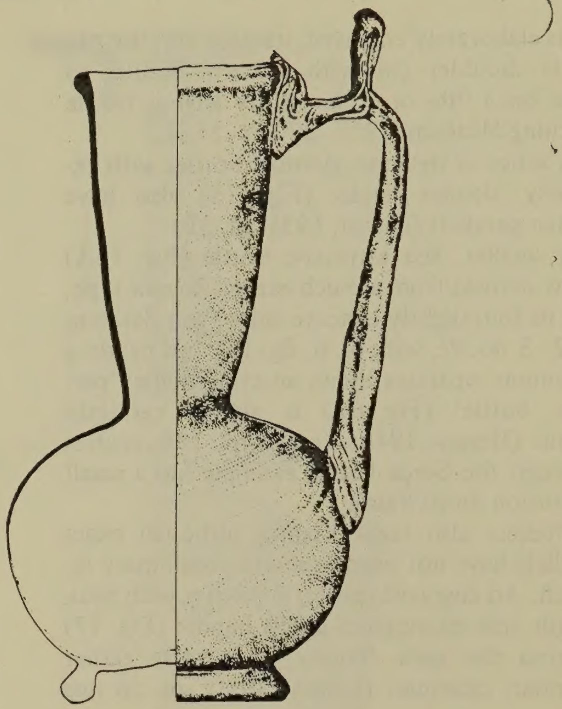

Figure 18. Glass jug GW 94. Scale 1 : 2.

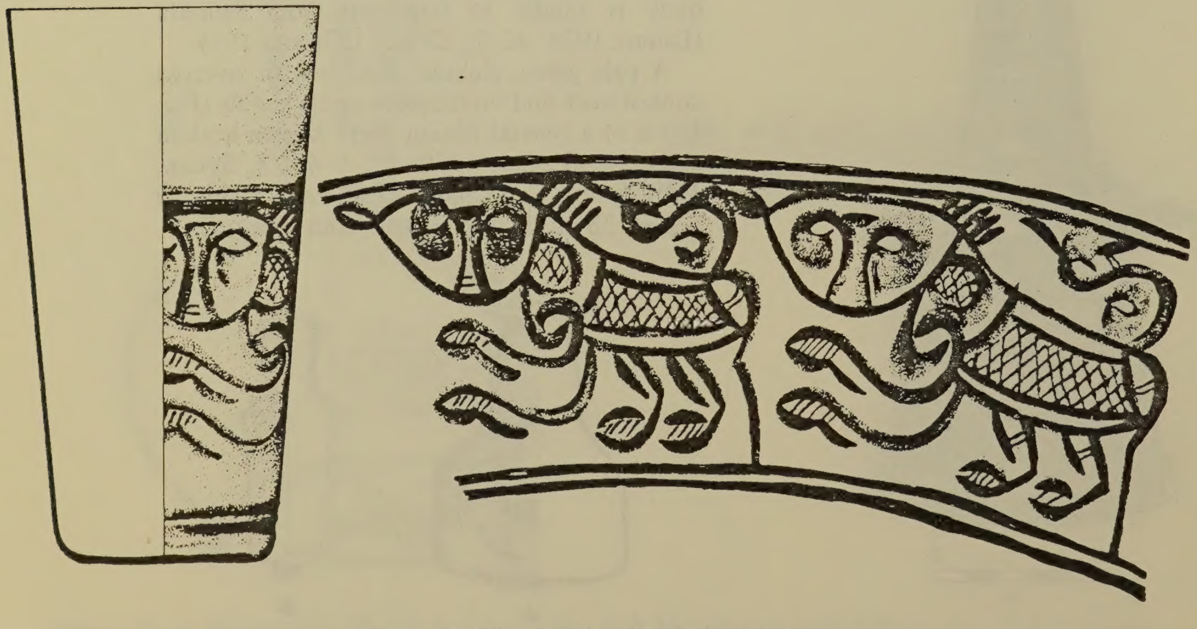

Figure 19. Glass tumbler GW 98. Scale 1 : 2.

Tumblers are engraved with architectural designs, curvilinear patterns, or, in one case, by lions (Fig. 19) matching those on the bottle found next to it (Fig. 13B).

Approximately 200 different glass shapes were noted, ranging in colour from clear through various hues of green, yellow, blue and purple. Besides those illustrated here, general categories included bowls, plates, one-handled cups, lamps, and jars—the last in an enormous variety of sizes.

Conclusions

It is far too early, both in the course of excavation and in preliminary research, to attempt answers to numerous questions raised by the 1977 campaign at Serçe Liman:

Was the ship an early example of modern skeletal building? What was her nationality? What was her final route and intended destination? What caused her to sink? Did the cargo originally comprise intact or broken glass? Was the glass all from the same workshop, or even from the same country? Were the vessel glasses from the same source as the cullet? Were itinerant glassworkers by chance on board?[4]

The mixtures of Byzantine Greek coins and Arab glass weights, and of Byzantine amphoras and Islamic glass in the cargo, point to the complexity of the questions.

We may suppose, until future evidence might prove otherwise, that the ship sank in or shortly after AD 1024/5. We may further suppose, on the basis of what seem to be the crew's pottery and buckets (one bearing an Arabic inscription), that the ship was in Moslem hands.

Beyond that it is difficult to make suppositions. We might guess, at first, that the cargo of glass, at least, was taken on in one or more Islamic ports. But it should be stressed that it is the *intact* glass found near eating wares that has been identified as Islamic, and these pieces may have been possessions of crew or passengers. The difficulty or impossibility of differentiating between 'Islamic' and 'Christian' glass, or even defining 'Byzantine' glass has been stressed (Corning Museum, 1957: 190–91), and we must face the possibility that a Moslem ship had taken on a cargo of broken Byzantine glass and cullet.

The cargo amphoras were lined with resin, suggesting that they contained wine (stoppers still in place in several have not been removed). Although Moslems were not above dealing in 'prohibited' wine (Goitein, 1967: 122–23; 1973: 19), Jews and Christians, often Monks, may have borne the greater part of the wine trade (B. Spuler in Richards, 1970: 13). Thus, one supposes, the cargo amphoras could have been obtained either from a Byzantine port or from a Christian merchant living in a Moslem country.

Although most of the shipboard pottery seems Islamic, and some even Egyptian, it could presumably have been picked up at any of numerous Moslem ports. Trade, even in times of war, seldom stopped between Moslem countries (Spuler in Richards, 1970: 11), or even between Byzantine and Moslem ports (Lewis, 1951: 214).

Further, it is often difficult to identify the provenance of Islamic pottery because potters travelled frequently, producing identical wares in different countries (Carswell in Richards, 1970: 63).

Intact glass on board serves no better than the pottery in suggesting the port or ports at which the ship stopped on her final voyage. Although the best and most numerous good parallels for the Serçe Liman glass are to be found in Persia, it is most difficult to distinguish between glasswares of Persia, Mesopotamia, Syria and Egypt (Pinder-Wilson & Scanlon, 1973: 15). The same styles were popular throughout these countries, and, as mentioned above, trade was intense. Syro-Palestinian glassmakers poured into Egypt in the 11th and 12th centuries, competing with Egyptian glassmakers (Goitein, 1967: 45), including Jewish glassworkers (Goitein, 1973: 18) who sometimes worked in partnership with Moslems (Goitein, 1967: 85). It has even been suggested (Corning Museum, 1957: 191) that 'some glass factories must have changed from Islamic to Byzantine control, or vice versa, with little if any effect on the type of product they turned out.'

Scientific analyses of wood, glass, and pottery may help answer questions regarding the origins of the ship and its contents. These answers, in turn, could tell us much about the manufacture and trade of medieval glass in the Eastern Mediterranean.

Acknowledgments

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Staff, besides the authors, included Cynthia J. Eiseman, Donald A. Frey, Jack W. Kelley, Robin C. M. Piercy, and Tufan Turanli of INA; artist Gündüz Gölönü; physician John Cassils; Ali Manisali, Hasan Incirioglu, Osman Pekin, and Barlas Çaglayan, students from Boghazici University, taught to dive by instructor Wade Hahn assisted by Tom Dickenson; Texas A&M students Lisa Shuey and Donald H. Keith; Cemal Pulak, Ayhan Sicimoglu, Sina Mandalinci and Omer Zeki Elbi, veterans of Sheytan Deresi; and Faith Hentschel, Susanne Biehl, Jean Kelley, Gay Piercy, and Paul Johnston. Oguz Alpözen represented the Turkish Ministry of Culture as commissioner, assisted by Yüksel Egdemir. We appreciate the help and advice given by Nixon Griffis, John H. Baird, Robert Brill and Frederick Matson on their visits to our camp.

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Notes

[1] Frames 2 and 5 may be slightly wider, but this is not certain.

[2] Although the keel is not rabbeted, the sternpost remnant has shallow rabbets at the very top of its side faces to receive the after ends of planking strakes. The planking was fastened to the sternpost by iron nails.

[3] We had no scales in camp to weigh these, and most artefacts were packed for winter storage in the Bodrum Museum before leaving camp.

[4] Dr Robert H. Brill of the Corning Museum of Glass raised several of these questions, which he hopes to answer by chemical analyses of vessel glasses and cullet.

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Report No. 5

Deepwater archaeology. The Capistello wreck excavation, Lipari, Aeolian Islands

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The excavation

Because of persistent destruction of ancient shipwrecks by amateur divers and professional looters, wrecks in relatively shallow depths are disappearing at an alarming rate. Although many sites picked clean of surface and near-surface finds still warrant archaeological investigation, and untouched wrecks within the reach of SCUBA diving still await discovery, the nautical archaeologist's most difficult task in the future may be locating sites worthy of excavation.

The technology to investigate deeper wrecks is in common use by the offshore drilling industry, but the prohibitive cost of mixed-gas diving and the elaborate equipment required to work safely at these depths would normally preclude its use for archaeology. However, in a unique collaboration, the Institute of Nautical Archaeology has worked with saturation-diving trainees from Sub Sea Oil Services of Milan (SSOS) to investigate a 3rd century BC shipwreck lying in 60 m of water. During the summer of 1977, eleven SSOS trainees spent a total of 157 man-hours excavating the wreck site under INA's archaeological direction.

History of the Capistello site

The Capistello reef and the shipwreck named after it both lie close to the coast of Lipari, one of the seven Aeolian Islands 50 miles northwest of the Straits of Messina (Fig. 1). While several individuals claim to have discovered the wreck, all agree that it was found in the mid-1960's. A large amount of material removed clandestinely from the site was confiscated by Italian authorities in 1967 and is now on display in the Museo Eoliano in Lipari; this includes over 30 amphoras and several hundred examples of Campanian A black-glazed pottery. Another, much smaller sequestration took place the following year. By then the wreck had attracted considerable interest, and in the summer of 1969 an expedition from the German Archaeological Institute at Rome began a survey of the site. After ten days it ended tragically when a diving accident took the lives of the expedition director, Helmut Schläger, and one of his colleagues; a third member of the team was paralysed permanently. More material illicitly removed from the wreck was confiscated in 1971. All the sequestered material has now been published (Blanck, 1978), but for five undergoing saturation training would devote their bottom time to further exploration and excavation of the Capistello shipwreck under INA archaeological direction.

Physical description of the site

The Capistello shipwreck lies on a very steeply sloping bottom, averaging about 45°, approximately 300 m off the south-east coast of the island of Lipari and 200 m from the Capistello reef (Fig. 5). The bottom in the vicinity of the wreck consists mainly of various sizes of boulders and isolated bedrock outcrops interspersed with patches of loose sand and small shells.

Before excavation the site appeared to be an unusually large sandy patch at 59 m, below which spilled a talus of shattered and intact amphoras to a depth of about 90 m. Results of the 1977 excavation indicate that at least some of the boulders scattered around the site arrived at their present positions only after the shipwreck reached its final resting place. Excavation was somewhat limited by concern for undermining these boulders and causing a submarine landslide. Further, excavated areas often quickly filled in again with loose sand cascading down from farther upslope.

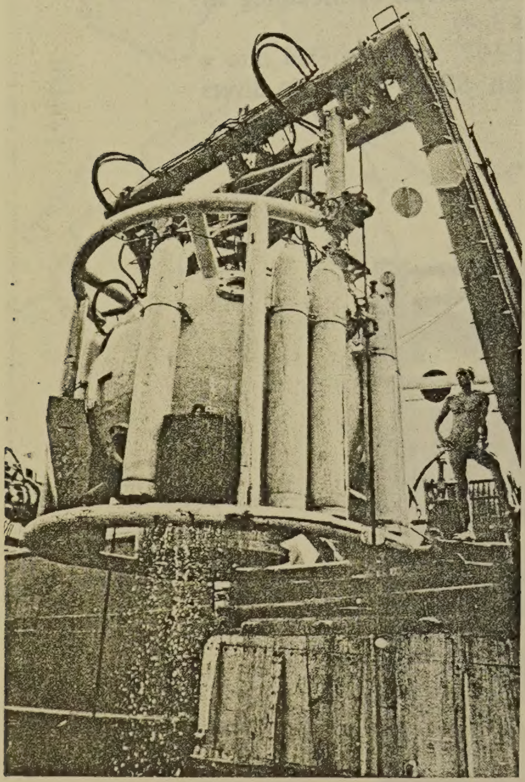

Figure 4. The diving chamber.

As excavation progressed, it became increasingly evident that the relatively flat ledge over the wreck site was caused by the cargo of the ship trapping sand flowing down from upslope, rather than being the reason for the ship lodging in its present position.

It is also clear that the long axis of the ship lies perpendicular to the direction of the slope and seems to have been partially supported in antiquity by 'Roccia di Matteucci', thought to be a bedrock outcrop rather than a loose boulder. The discovery of a large portion of the hull intact on the sand ledge above this outcrop indicates the ship settled here, with only displaced cargo lying in deeper water.

Methods

During the month of August and the first week of September, SSOS conducted three saturation training dives of five, nine and seven days duration respectively. In addition, 33 hours of decompression were required by each team of divers at the ends of their saturation periods. Teams were comprised of four divers working in pairs, one pair diving in the morning and the other in the afternoon. Typical bottom time for each diver was two hours; while one diver worked on the wreck his partner remained nearby in the diving bell to observe him and control the technical aspects of his dive. The three teams logged a total of 157 hours 19 minutes on the site, during which time the main activities were continued excavation, photographic documentation and the raising of artefacts.

On the site, divers had continuous diver/surface communication by telephone and were monitored by closed-circuit television. However, our lack of direct contact with the divers was one of the most unsatisfactory technical aspects of the operation. The INA television system had limited definition and required constant repositioning to follow divers under water; moreover, sand clouds raised during excavation generally obstructed our view of the work. Telephone communication was equally poor. Divers had difficulty hearing in their helmets, perhaps because of the sound of their own breathing, and frequently had to leave their work and return to the diving bell to understand messages passed to them. Further, the special mixture of helium and oxygen that they breathed under pressure gave their replies a high pitched 'Donald Duck' squeak, causing surface operators frequently to limit divers' replies to only 'affirmativo' and 'negativo'.

Fortunately, these problems were partially resolved by the use of the SSOS submersible *P51* (Fig. 6). The high manoeuvrability of the submarine and the skill of its pilots allowed us a close view of the excavation as it progressed, particularly when the remains of the ship's hull gradually came to light. *P51* is equipped with a high-resolution, wide-angle television and videocorder system with which we could pass over the wreck and videotape its details for study on the surface and use in drawing a site plan. With the exception of close-up photographs taken by divers, the TV images were generally the most distinct records of the site we were able to obtain.

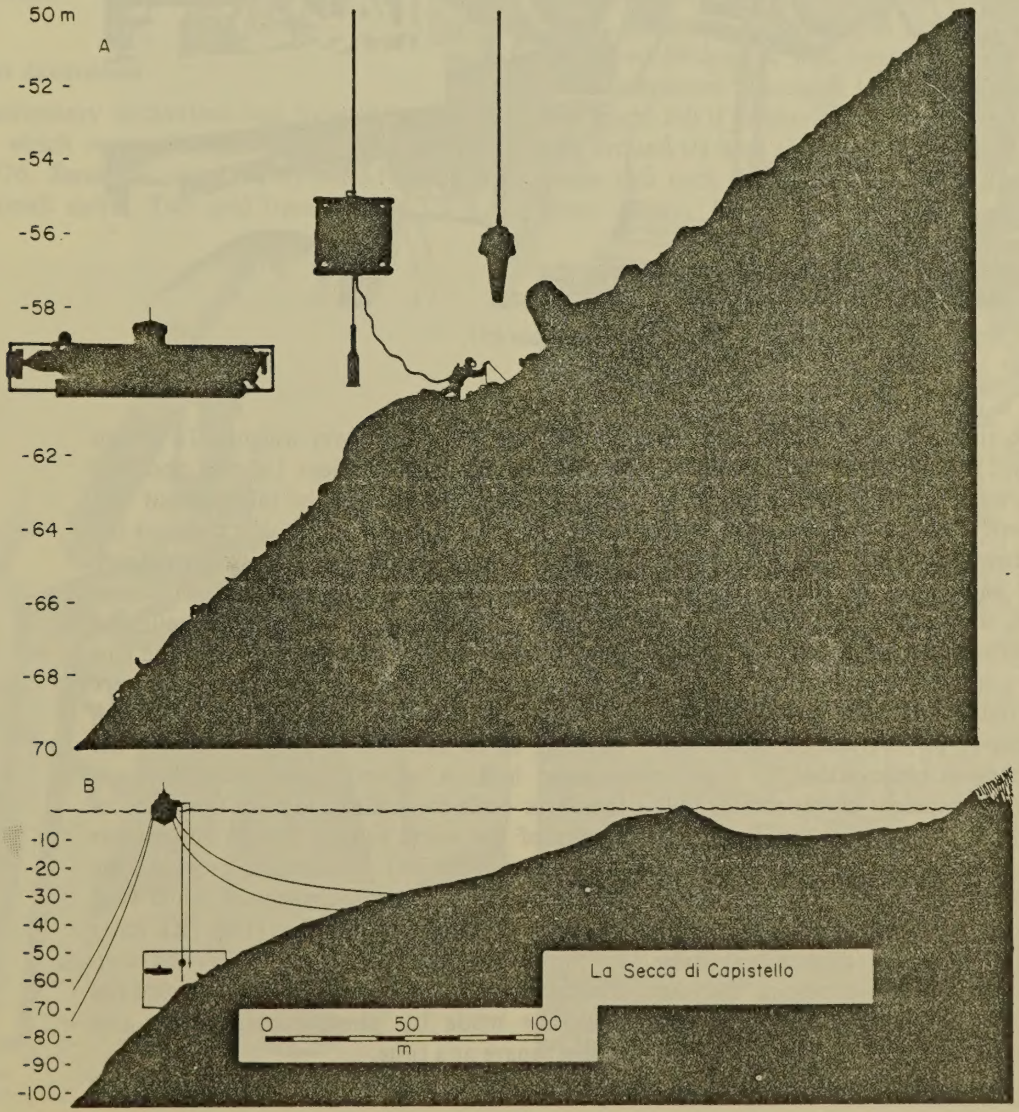

Figure 5. Profile of wreck site showing ship, diving bell and submersible.

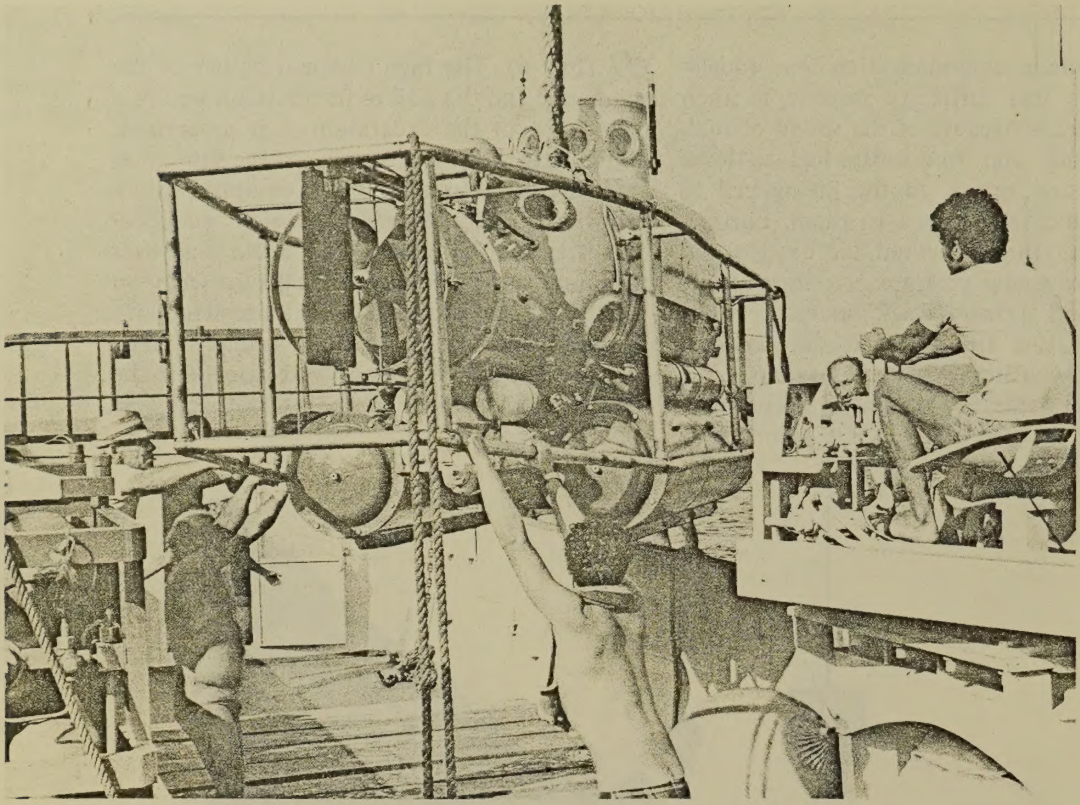

Figure 6. The SSOS submersible *P51*.

Excursions to the site were also made in the Robertina (Fig. 2) diving bell. In comparison with the *P51* it was extremely awkward and of limited usefulness. Only four of its many windows looked downwards towards the seabed and were large enough to be practical. More often than not the area of interest lay just between two of the windows, spaced 90° apart. Encumbered by a carbon-dioxide scrubber backpack it was difficult for the observer to move between windows to photograph or sketch the site and take notes on observations.

Early in the campaign considerable hull remains were found just under the amphoras exposed during the previous season. In order to document these remains in the low light level, natural-light photographs usually were taken at 1/30 of a second with the camera lens fully open. This created serious problems for the SSOS divers who had little or no experience with underwater photography and were impeded by umbilicals to the bell, clumsy heated diving suits, gloves, and very heavy weights. To obtain bottom details with ambient lighting and visibility, photographs had to be taken about one metre from the bottom, and at that distance the depth of field for a fully open lens is minimal. The problem was overcome by the construction of rigid, portable photo towers which allowed time exposures of several seconds with the lens closed to its smallest aperture. The results were rewarding in sharpness and clarity of detail, enabling us to assemble a photomosaic of the exposed hull. A second, much smaller tower then was built for taking close-up flash photographs of the wood using a special underwater macro-lens (Fig. 7A). The results provided the first view of the mortise-and-tenon joints used to fasten the strakes of the ship (Fig. 7B). Later in the season a third, larger tower was constructed so that a photomosaic of the entire site could be made by photographing areas one metre square at a time.

While the excavation was in progress divers were provided with journals to record their activities and the location of finds they sent to the surface. A Mylar map of the site was locked into their chamber so that they could locate finds precisely. Saturation teams were briefed before they entered saturation and debriefed on their return to normal pressure. With some difficulty divers were also interviewed while still under pressure in the chamber. To facilitate underwater tasks, such as measuring features of the hull and identifying amphoras on the bottom, divers were sometimes provided with Mylar maps which they took to the site in order to enter information and comments while they worked.

The excavation

Preliminary excavation was focused on the area in which rows of amphoras were discovered in 1976. Sand was removed by hand-fanning and a small airlift. Two grid frames, each 2 x 4 m, were also laid down in the area. The removal of newly cleared amphoras brought to light frames and strakes of the ship's hull (Fig. 8), and subsequent excavation followed the exposed frames. A simultaneous survey of the surrounding seabed with *P51* disclosed six lead Roman anchor stocks and one iron anchor scattered around the foot of an unusually large submerged rock *c*. 100 m north-east of the site, and two more lead stocks immediately below the wreck site at depths of 72 and 88 m.

Following the ship's hull in the upper right-hand corner of the gridded excavation area (Fig. 9), divers encountered a number of pieces of Campanian ware which were photographed and raised. However, excavation in this area had to be halted because it was feared that the large rock nicknamed 'Roccia di Lupoli' was unstable and might fall if further excavation were carried out around its base (Fig. 10). In a future campaign this rock should be removed if it can be done safely. Following the hull downslope

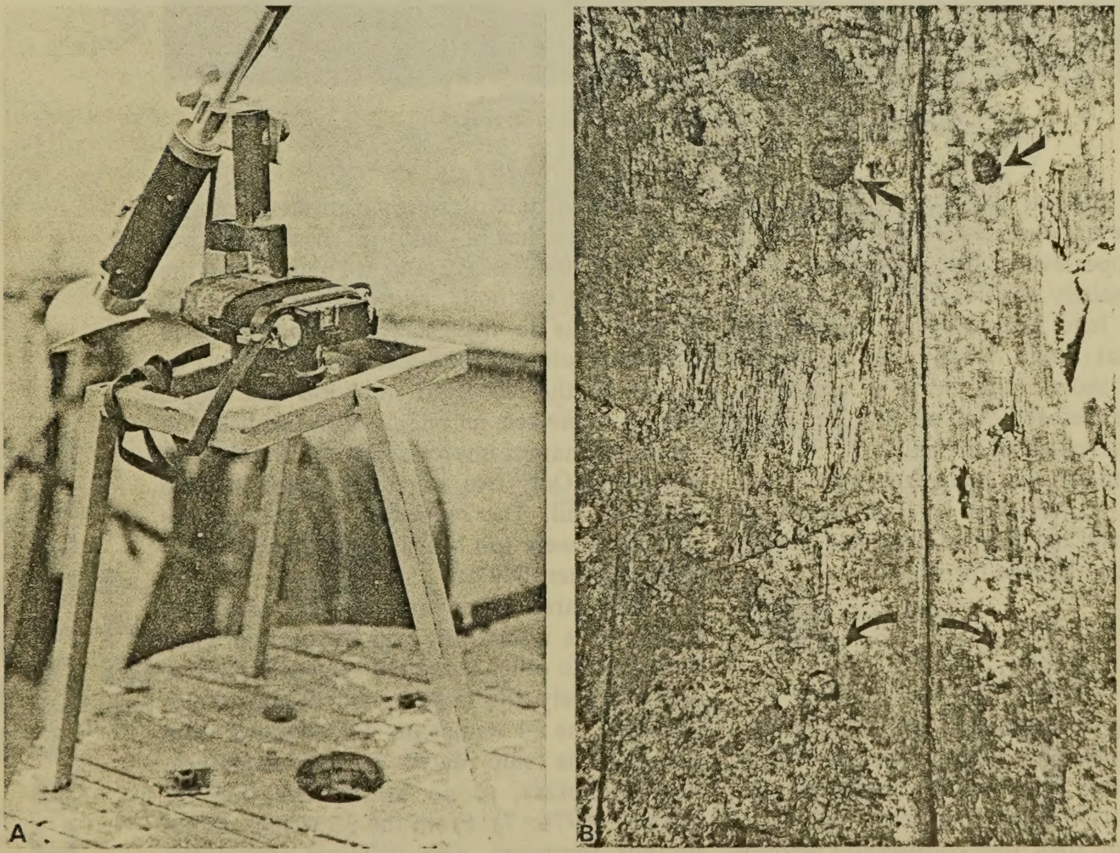

Figure 7. A. Photographic tower used for close-up of wood; B. photograph showing mortise-and-tenon joint.

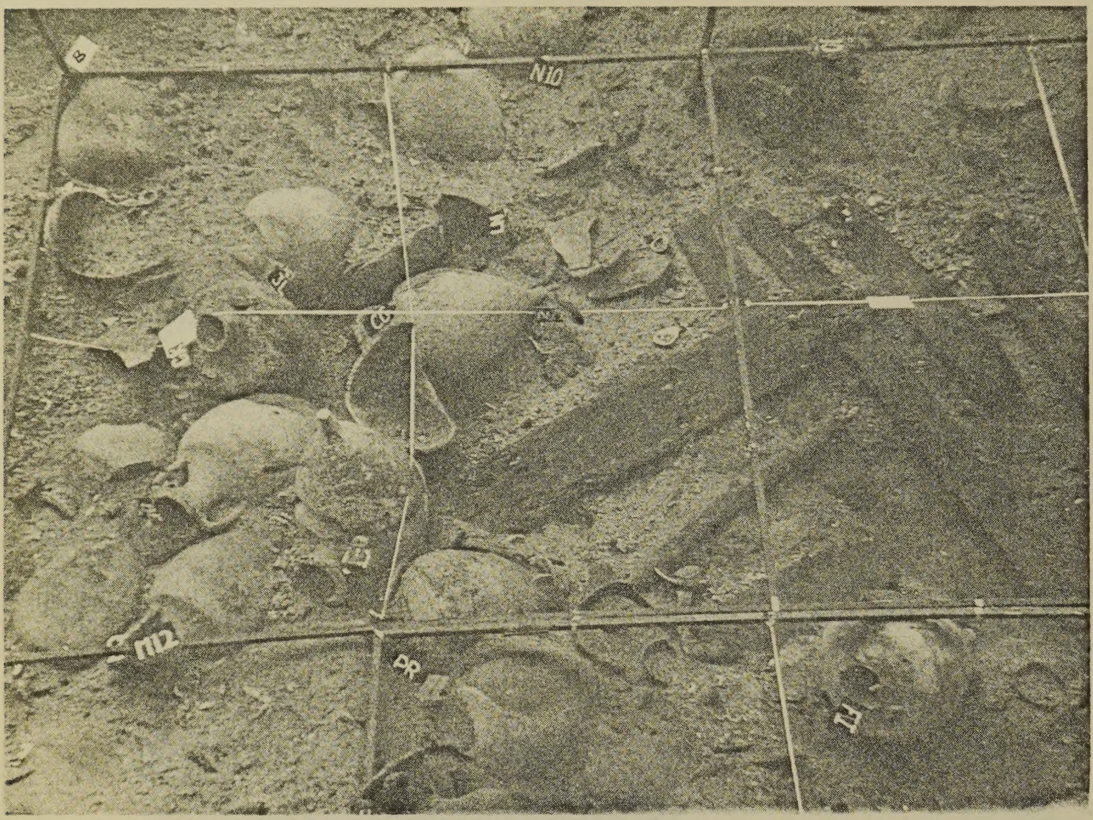

Figure 8. Amphoras lying above frames and strakes.

proved more difficult because the sand is much deeper. However, once the divers were able to remove the upper level of sand they encountered a layer of regularly positioned amphoras firmly embedded in hard mud and shell. Most of the amphoras that could readily be freed were raised while those more firmly concreted in position were removed only where necessary to extend the excavation of the hull.

At the end of the campaign the site was covered with a protective layer of sand from the slope above and bags of sand and pebbles from the beach opposite the site.

DONALD A. FREY

The cargo

More than eighty amphoras were discovered on the seabed under only a slight covering of sand. In the grid area most of the amphoras were found in uniform rows of at least four to six amphoras each, their toes consistently pointing upslope. Fifty-two were recovered, mostly intact. They had a uniform shape and size, measuring 0·62 m tall and 0·36 m across the shoulder of the body, allowing for minor differences due to the necessary imprecisions in the manufacture of hand-made pottery (Fig. 11). Thirty of the recovered amphoras had legible stamps impressed on one or both handles, and three had stamps impressed on the shoulder of the body. Only two amphoras clearly had no stamp at all. The remaining 17 had handles missing or were too heavily concreted to determine whether they had a stamp or not.

Thirty-three visible stamps on 52 recovered amphoras is a relatively high proportion when compared to other excavated cargoes datable to approximately the same period. Compare, for example, the 24 stamps on 404 amphoras from the Kyrenia ship dated by the excavator, Michael Katzev, to no earlier than 306 BC (Katzev, 1976: 7). From the 33 visible stamps on our amphoras, nine different stamp dies

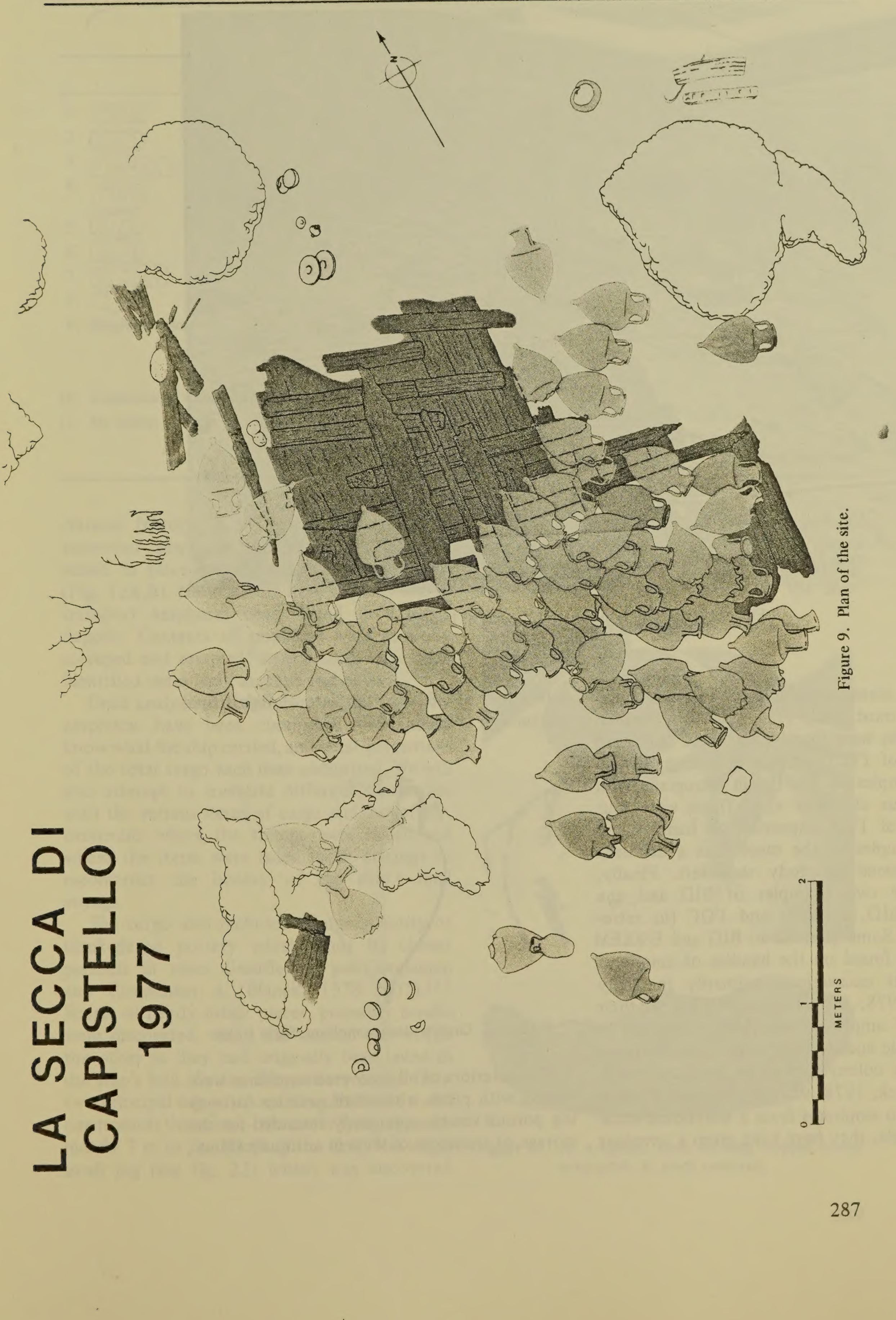
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Figure 9. Plan of the site.

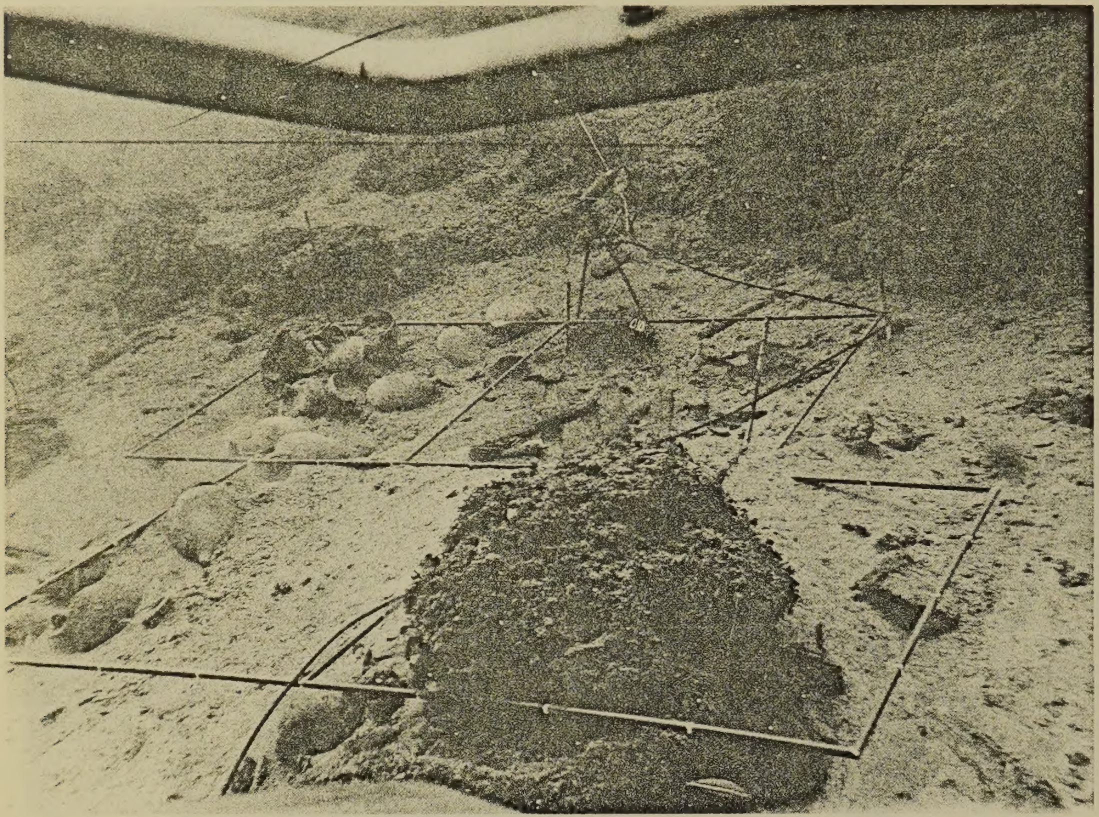


Figure 10. Pottery lying around 'Roccia di Lupoli'.

have been identified (Table 1). The most common and most easily read is ΓΑΡΗ of which 11 examples were found; there were also seven examples of ΓΙΣΤ written in retrograde and three examples of ΧΑΡΗΣ in retrograde with a cadeuceus at either end. There were four examples of ΓΑΡ impressed on handles and three examples of the same (but a different die) impressed on body shoulders. Finally, there were two examples of ΒΙΩ and one each of ΔΙΩ, ΕΨΞΕΜ and ΓΟΓ (in retrograde).[1] Some parallels to ΒΙΩ and ΕΨΞΕΜ have been found on the handles of amphoras from other excavations, primarily in Sicily (Blanck, 1978: 96–7). On the basis of their shape, our amphoras have been identified as Graeco-Italic and, were probably manufactured at a Greek colony located in Sicily or South Italy (Blanck, 1978: 96). On the basis of their similarity to amphoras from a warehouse excavated in Gela, they have been given a *terminus ante quem* of 282 BC, the date of Gela's final destruction (Blanck, 1978: 97).

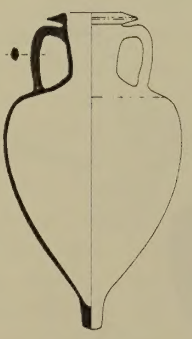
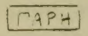
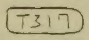
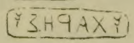
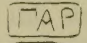
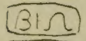
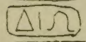
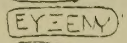
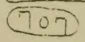


Figure 11. Graeco–Italic amphora. Scale 1 : 10.

The interiors of all recovered amphoras were coated with pitch, a standard practice for sealing porous vessels commonly intended for the storage or transport of wine in antiquity (Pliny,

Table 1. *Amphora stamps*

		1977	1976
1. 		11	1
2. 		7	–
3. 		3	3
4. 		4	–
	(on shoulder)	3	–
5. 		2	4
6. 		1	–
7. 		1	1
8. 		1	–
9. Illegible stamp		–	3
		33 visible stamps	12 visible stamps
10. Existence of stamp uncertain		17	–
11. No stamp		2	7
		52 recovered amphoras	19 recovered amphoras

Natural History, XIV. xxiv). Fifteen of the recovered amphoras still have cork stoppers sealed in place with a thick coating of pitch (Fig. 12A,B). Never before have so many sealed transport amphoras been found in a single deposit. Contents of amphoras were carefully screened and sampled; several seeds have been identified tentatively as grape and olive.

Once analyses of organic materials from the amphoras have been completed, we should know what the ship carried, and what percentage of the total cargo each item comprised. We will also attempt to correlate different stamp dies with the various items of cargo and, hopefully, determine where the stamps were issued and where the items were laded in an attempt to reconstruct the history of the ship's final voyage.

The cargo also included a large quantity of black-glazed pottery which finds its closest parallels in vases classified as pre-Campanian and Campanian A (Blanck, 1978: 107).[2] Scores of nearly intact pieces, primarily bowls, were discovered, many still stacked one within the other as they had originally been laded in the ship's hull. So far, this pottery comes from two principal deposits, one towards the bow and one towards the stern – the latter lying approximately 7 m to the south of the first. The single small jug (see fig. 23) which was discovered just upslope of the southern deposit appears to have comprised part of the galley ware and indicates that the adjacent pottery deposit was laded in the after portion of the ship.

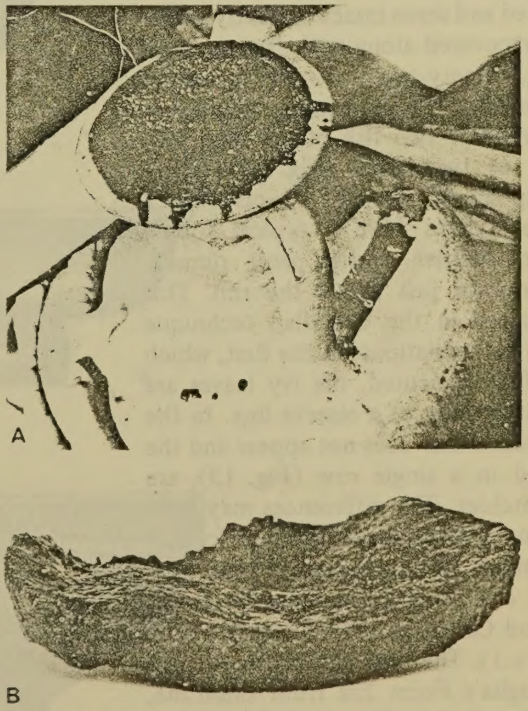


Figure 12. A. Amphora neck showing stopper closed with pitch; B. pitch removed.

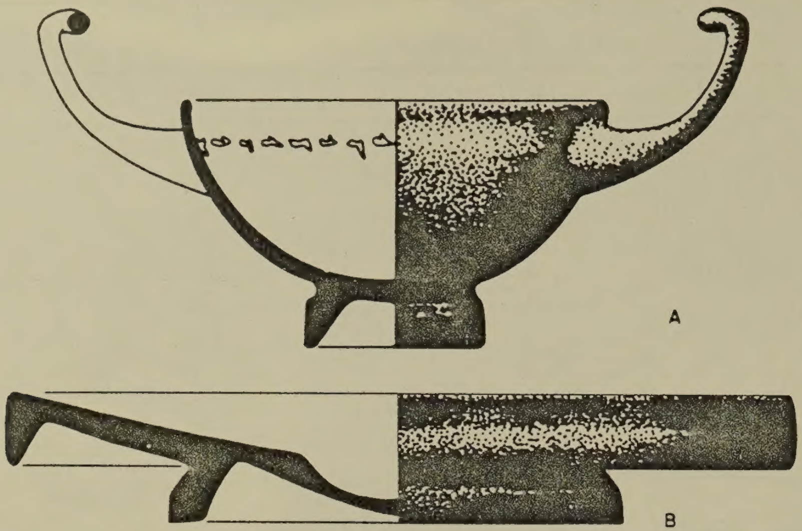


Figure 13. A. Campanian kylix; B. Campanian fish plate. Scale 1 : 2.

These two deposits of Campanian pottery were separated by the mass of amphoras stacked amidships. There was no evidence that the stacks of bowls were laded to fill space between the rows of amphoras as had been suggested by Blanck (1978: 93 and 108).

One hundred and seven intact or nearly intact vessels were recovered along with fragments of many others. Ninety-seven of the recovered pieces are bowls. The remaining ten pieces include six kylikes, two fish plates (Fig. 13), and portions of two lamps (Fig. 14). These shapes correspond to Blanck's Forms 10, 11 and 12. The kylikes have a typical foliate decoration in fugitive white paint running around the interior just below the rim. This motif is executed in the Gnathian technique and is seen in two variations. In the first, which is more carefully executed, the ivy leaves are painted on either side of a reserve line. In the second, the reserve line does not appear and the leaves, painted in a single row (Fig. 13), are somewhat sketchier. The differences may indicate that two painters decorated the kylikes thrown by a single potter. Parallels to this type of decoration can be found among the pieces from the Grand Congloué cargo (Benoit, 1961: pl. v, a.3 and c.1). The best parallel to our fish plates, Lamboglia's Form 23a from Ensérune, has already been cited by Blanck (1978: 104).

The bowls have three basic shapes, all of which occur in a variety of sizes and proportions. First, there are echinus bowls with vertical walls which generally have a single seven-

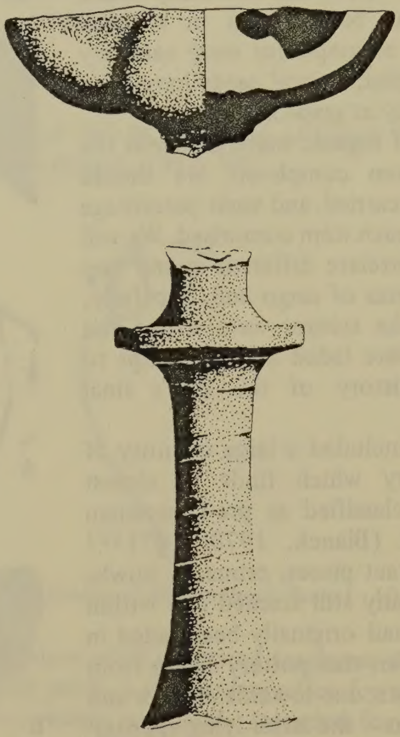
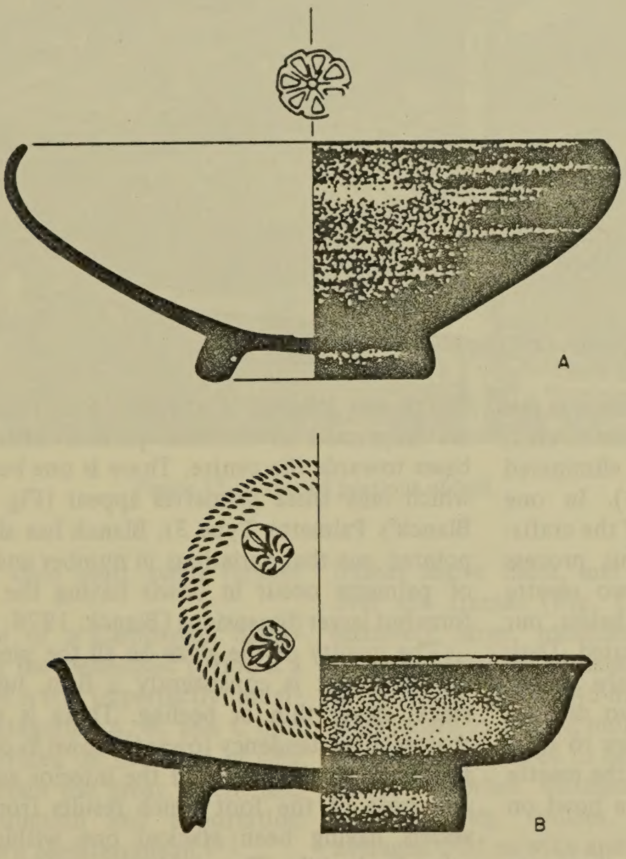


Figure 14. Campanian lamps. Scale 1 : 2.

petalled rosette (Fig. 15A). The bowl with the incurved rim was one of the most common forms to inundate the coasts of the Mediterranean during the Hellenistic period (Fig.15C). Blanck had cited Lamboglia's Forms 25 and 27, both from Ensérune, as close parallels to our bowls of this shape. To the third basic shape belong the slightly carinated bowls with outturned rims (Blanck's Form 8), the centres of which are impressed with palmette stamps surrounded by spirals of rouletted strokes (Fig. 15B).

The stamps have not yet been studied in detail, and it is not known precisely how many stamp dies are involved.[3] The same stamp can also produce widely varying impressions depending upon the precision of its application to the bowl. The face of the stamp was slightly convex and required a circular movement of the hand in order that every part of the design leave



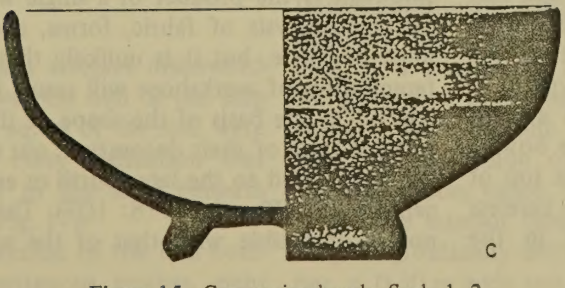


Figure 15. Campanian bowls. Scale 1 : 2.

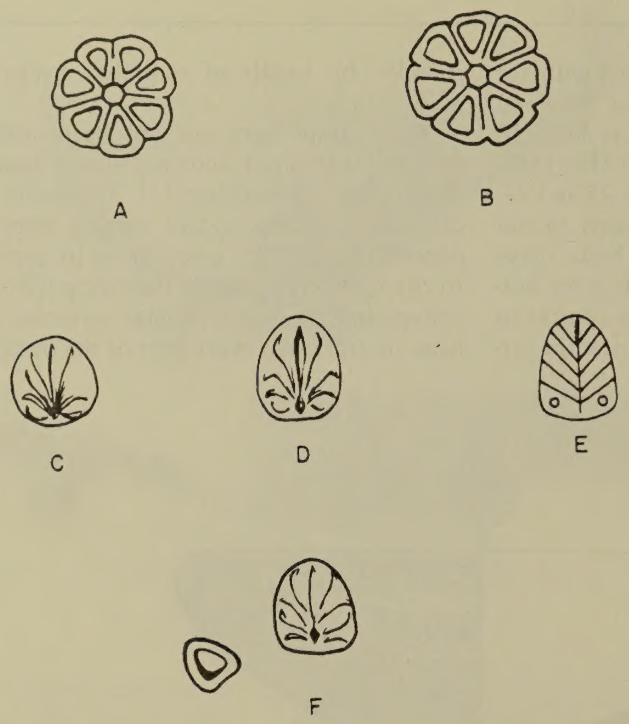


Figure 16. Stamps on Campanian bowls. Scale 1:1.

an adequate impression. If the rotation was not complete or the pressure unevenly distributed, certain parts of the design could be eliminated or distorted (Corbett, 1955: 173). In one example from our cargo the hand of the craftsman must have slipped during this process because only the outer edges of two rosette petals are barely discernible. Nevertheless, our rosettes in general are carefully executed. They are all seven-petalled and remarkably similar except in dimension. There are two distinct sizes (Fig. 16A,B), and there appears to be a correlation between the diameter of the rosette and the diameter of the foot of the bowl on which it is impressed.[4]

In the case of the palmettes, there are clearly a number of different stamp dies. Some are free and curvilinear, other stylized and stiff (Fig. 16C–F). There is one stamp, however, which is repeated more frequently than the others (Fig. 16C; Blanck's Palmette Type 1). It is also clear that the rouletting was applied before the palmettes, because on one bowl a palmette was haphazardly stamped on top of the rouletted strokes. In this same careless example, another of the palmettes in the design was inverted. Generally, four palmettes are impressed in a radial pattern with their bases towards the centre. There is one bowl on which only three palmettes appear (Fig. 16D, Blanck's Palmette Type 3). Blanck has already pointed out that variations in number and type of palmette occur in bowls having the same form but larger dimensions (Blanck, 1978: 103).

The quality of the glaze on all the pieces in our shipment is consistently a firm, lustrous black, never thin or peeling. There is also a characteristic tendency towards brown in certain areas such as the centre of the interior and the underside of the foot which results from the vessels having been stacked one within the other in the kiln. The consistent quality of the glaze is a good indication that our entire pottery shipment is the product of a single workshop. Further analysis of fabric, forms, and stamps must be made, but it is unlikely that any differentiation of workshops will result from this study. On the basis of the shape of the vessels and the style of their decoration, our shipment has been dated to the late fourth or early third century BC (Blanck, 1978: 107). This date is not incompatible with that of the amphoras,

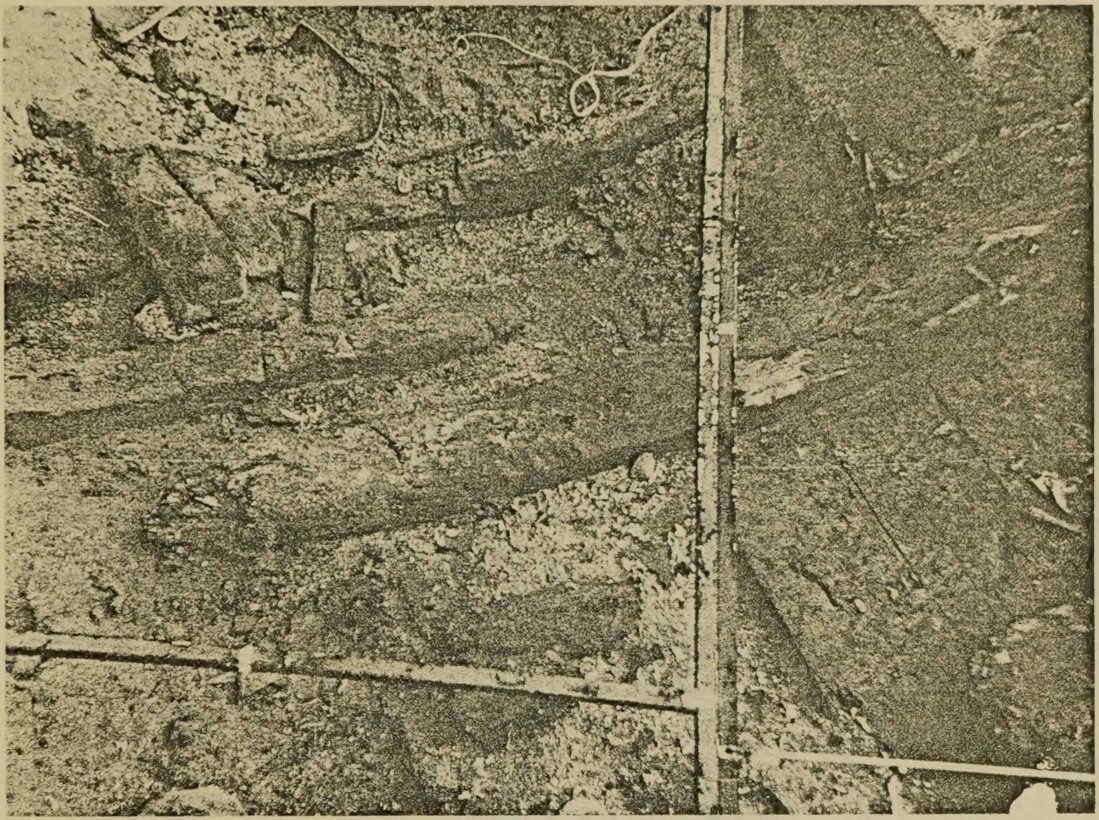


Figure 17. Exposed portions of hull.

but a more precise date must await further excavation.

The omnipresence of a Campanian black-glazed pottery during the Hellenistic period is a complex reality which is still imperfectly understood. The simple categories A, B, and C into which it had been divided on the basis of clay and glaze hardly explain the great extent and variety of its production and exportation throughout the western Mediterranean.[5]

FAITH HENTSCHEL

The hull

The single most important artefact discovered during the excavation was the hull of the ship itself. Approximately 6 sq. m of the hull were exposed and there is every indication that much more lies buried in the sand beneath undisturbed amphoras (Fig. 17).

The main exposed section of the hull comprised eight to ten contiguous strakes, eight frames above them, and three interior planks over the frames (Fig. 18). The frames were relatively large, moulded 0·10 m and sided 0·16 m. Measured strakes averaged about 0·20 m in width, and 0·045 m in thickness. Strakes were joined by pegged mortise-and-tenon fastenings which appeared to be rather widely spaced; divers reported distances of 0·16–0·185 m between peg centres. Mortises examined averaged 0·05 m wide and 0·06 m deep.

The frames formed a pattern of floors and futtocks alternating with half-frames. Half-frames occasionally consisted of sections scarfed together, but floors and futtocks were separated by a distance of at least 0·15 m. Frames were attached to strakes by copper nails driven through from outside the hull and clenched over on the inside of the frames. Distance between frames varied, but was about 0·15 m.

A large interior timber was discovered running longitudinally across six frames. This timber, *c.* 0·30 m wide and 0·06 m thick, may have

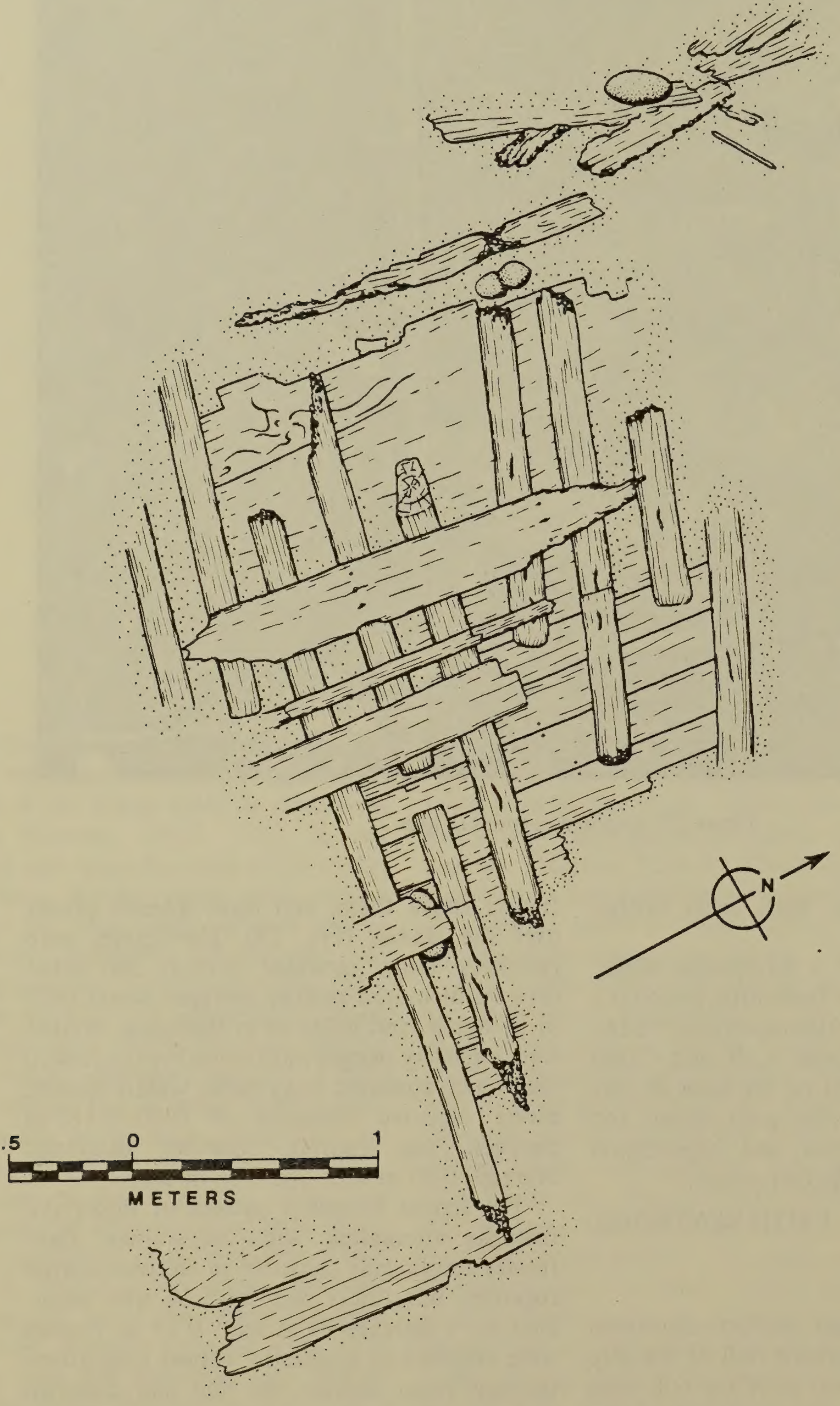

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Figure 18. Plan of hull.

been a clamp or stringer designed to strengthen the hull from inside. Two other interior timbers were discovered which may have been the remains of ceiling planking. A wooden pole, round in section and *c.* 0·07 m in diameter, was discovered lying adjacent and parallel to the stringer but unattached to the hull. 1·5 m of this pole was uncovered without exposing its southern extremity. Its purpose remains obscure.

Divers reported brushwood dunnage beneath the amphoras and spread over the inside of the hull; a sample of this dunnage was discovered in a good state of preservation inside an amphora. The interior of the hull seems to have been originally coated with a thin layer of a dark tarry substance which the divers had to scrape away to find tenon peg outlines and the seams between strakes.

Samples were taken of strake, tenon, peg, frame, stringer, and dunnage wood to aid in identification, but these have not yet been analysed.

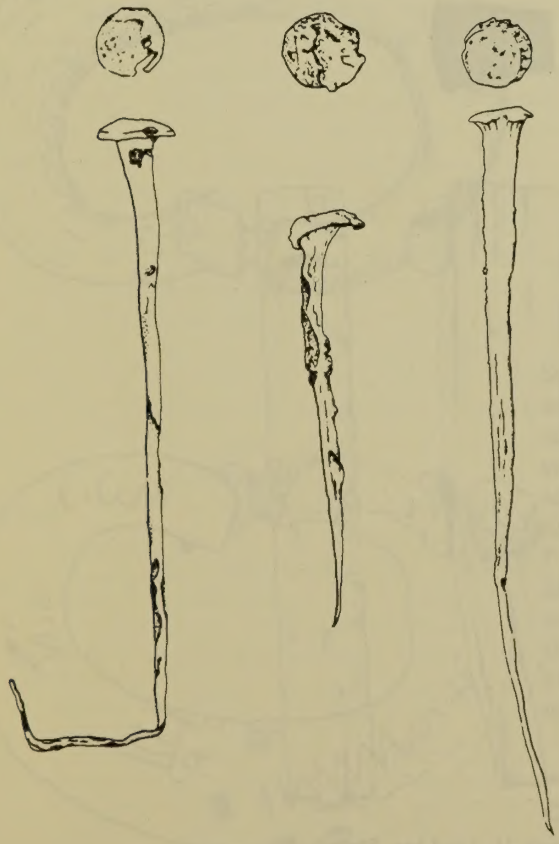

Figure 19. Iron nails. Scale 1 : 2.

A number of iron and copper nails were recovered. Most were bent or broken, but one example was found which retained the original 'clenched' shape (Fig. 19). The straight portion of the shaft of this nail was 0·15 m long, a figure which neatly coincides with the combined measured thickness of the frames and strakes (0·10 + 0·045 m).

The divers were asked to inspect the underside of the hull where accessible for traces of lead sheathing; none was found.

Although only a small fraction of the total hull was uncovered, it is possible to make some observations about its construction. First, the heavy construction evidenced by the frame and strake dimensions seems to indicate a ship comparable in size to the earlier Grand Congloué wreck (Benoit, 1961). The Kyrenia ship, of roughly a century earlier, had frames 0·08 x 0·08 m, strakes 0·35 m thick, and 0·04 x 0·04 m mortises in the strakes (Steffy, 1975: 88). This evidence strongly suggests the Capistello ship was considerably larger than the 15 x 5 m Kyrenia ship.

Correct interpretation of the exposed features of the hull cannot be accomplished without benefit of complete excavation, but a description and tentative analysis of those features is offered here. Divers reported the majority of frame nails clenched in a direction pointing upslope, suggesting the keel lies in that direction. This conclusion is substantiated by the distribution of undisturbed amphoras. Excavation upslope of the main portion of exposed hull was frustrated by large quantities of sand flowing down from the slope above. In this area some very fragmentary wood remains were discovered, possibly the keel and lower parts of the hull that were supported by rocks in antiquity and were largely destroyed by marine borers. Additionally, some of these wood fragments lay beneath boulders – perhaps the result of an ancient submarine landslide.

Ship's equipment

A number of different lead objects were raised, including three small weights, three large bars, and a curious 'pretzel-twisted' object of obscure function. One of the three small weights has the truncated pyramid shape of a modern line fishing weight, while the others are cylindrical

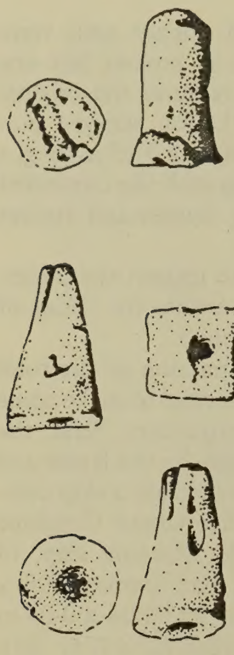

Figure 20. Lead fishing weights. Scale 1 : 2.

and conical in shape (Fig. 20). All three are about 0·04 m in height and 0·02 m in maximum diameter. The pyramidal and conical weights have small holes cast in the end with maximum diameter. All three weights were found by divers while excavating above the exposed hull area.

The three large bars and lead 'pretzel' were found just outside the main excavation area less than a metre north of 'Roccia di Matteucci'. The lead bars (Fig. 21) may represent parts of two lead-and-wood combination anchors of different sizes. All of the lead bars were trapezoidal in section, slightly curved longitudinally, and composed of various metal fragments cast in a lead matrix. Two of the bars were nearly identical in size and shape, having lengths of slightly less than 0·60 m, maximum heights of 0·12 m, and weighing 45 kg and 41 kg respectively. The third bar was much lighter, being only 0·51 m in length, 0·10 m in maximum height, and weighing 15·5 kg. A search was made for a possible mate to the third bar, but none was found.

In addition to these possible anchor fragments, an iron anchor was found approximately 5 m south of the grid frame. The anchor lay under a very thin layer of sand and was firs noticed by observers in the submarine. A sherd of Capistello site-type amphora was concreted to one arm of the stock, and other amphoras of the site-type lay nearby. However, two amphoras of a foreign type were found 2 m above the anchor, and the association of the anchor with the Capistello ship is not certain. The anchor was raised, measured and photographed, but since no conservation facility was available to treat it, was replaced on the site.

The iron anchor was slightly less than 2 m long, with an oblong shaft cross-section of 0·07 m maximum width. Width across the stock was 1·30 m. The stock was also oblong in cross-section, having a maximum width of 0·05 m. One of the arms was entirely broken off; the other, damaged in antiquity, was greatly shortened. The remaining portion of the arm joined the shaft at a very acute angle, a characteristic of known iron anchors from the Hellenistic period.

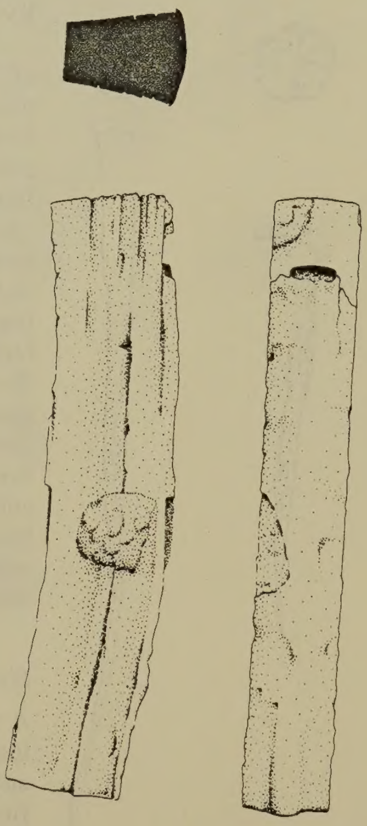

Figure 21. Lead bar. Scale 1 : 4.

The lead 'pretzel' found near the bars (Fig. 22) measured 0·28 m across and 0·20 m in width. The top side of the object was rounded and rough, as though cast in a sand or earth mould. The bottom surface was quite smooth, flat, and marked with numerous shallow scratches, some of which are too regular to have been entirely accidental. Further study of this artefact may lead to decipherment of the graffiti. It was suggested by Gerhard Kapitän during a visit to the site that this object may have been a line freer — a device slipped over a fouled anchor line and slid down it in an effort to clear obstructions. The object is shaped so that the open ends can be spread apart to take a rope, then closed again to prevent loss.

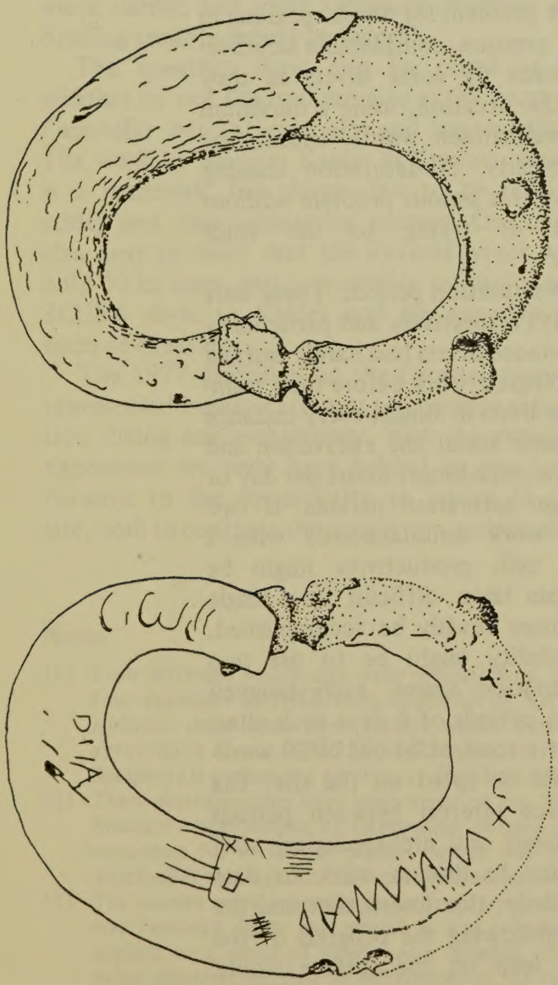

Figure 22. Lead 'pretzel' ring. Scale 1 : 1.

Two of three rounded river rocks found on the site are thought to have been ballast stones, but the third had grooves chipped into both sides as though to accept a line tied around its middle, perhaps to serve as a small anchor or sounding weight.

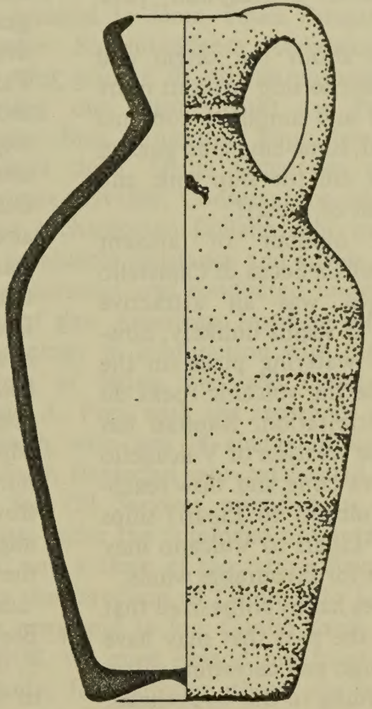

Figure 23. Pottery juglet. Scale 1 : 1.

The only ceramic object discovered other than the Campanian ware and transport amphoras was a small one-handled juglet 0·35 m tall (Fig. 23). It was found deeply buried and entirely free of encrustation in the sand at the southern limit of the excavation. It is almost identical to a juglet recovered from the Filicudi F wreck (early 3rd century BC) and now on display in the Lipari museum. If the juglet is not part of the cargo, but rather part of the ship's equipment, it may indicate that the stern of the Capistello ship lies to the south of the main excavation area.

DONALD H. KEITH

Conclusions

A great deal more is now known about the Secca di Capistello wreck as a result of the 1977 excavation. The distribution of finds on the bottom and size of the ship's timbers suggest the original length of the ship was 20 m or more. General construction characteristics are similar to those of the Kyrenia and Grand Congloué ships. Lead bars similar to those found at the Capistello site have been found at Kyrenia (Kapitän, 1973: 391), Porticello (Owen, 1971: 122), and Filicudi F (Kapitän, pers. comm.).

Little can be said about the origin and destination of the Capistello ship without more evidence. If the wood and amphora contents samples can be identified, some educated guesses can be made. But why did the ship sink, and why was she on the coast of Lipari?

The extraordinary number of ancient anchors in the vicinity of La Secca di Capistello suggests that the area was an attractive anchorage in antiquity. It seems unlikely, however, that there was a watering place on the mainland of Lipari since the volcanic rocks do not trap and hold precipitation. Kapitän has suggested that before the creation of Vulcanello (the recently formed lava cone and flow reaching northward from Vulcano to Lipari) ships attempting to sail from Lipari to Vulcano may have waited at this place for favourable winds.

Professor Bernabo Brea has hypothesized that a beach existed here in the past that may have been used for landing cargo and careening ships. A sea-level change, according to this hypothesis, could account for the subsequent erosion and disappearance of this beach. Whatever the conditions of the past, the hillsides rise precipitously behind this beach, and the much more attractive harbour of Marina di Port Salvo lies only 3 km to the north. A final theory suggests the Secca di Capistello area was used by smugglers or other clandestine traders who would have been willing to exchange the absence of port facilities for immunity from official inspection and regulation.

Recommendations for future work

The value of saturation diving to nautical archaeology was amply demonstrated in 1977 by the greatly increased bottom time spent on the wreck. However, since this was a pioneering effort, certain problems arose which impaired the efficiency of the operation. Some of these can be overcome, now that they have been identified, but others are inherent to saturation diving and may be insurmountable. Principal problems observed during the excavation, and some suggested remedies, are as follows:

1. Inability of the archaeologist to visit the site in person. The possibilities exist for an archaeologist to either make short mixed-gas dives on the site or be trained in saturation diving.
2. Failure to prepare the saturation divers archaeologically for the operation. Prior experience in underwater excavation and interpretation could be gained by the divers during a possible indoctrination course already under consideration. Divers must also learn to work without the pronounced negative buoyancy to which they are accustomed.
3. Diver-to-surface communication. While this is an inherent problem for divers speaking in helium under pressure, considerable improvement was made by some divers as they adjusted to the situation, using a minimum number of well-chosen words, enunciating slowly and clearly. Pre-saturation training might improve this serious problem without the expense of trying to use voice 'unscramblers'.
4. Brevity of the saturation periods. These were 5, 9 and 7 days respectively and particularly in the first instance divers had barely learned to do archaeological work before their training ended. The divers in almost every instance were enthusiastic about the excavation and were willing to work longer hours per day or stay for longer saturation periods. If two divers could work simultaneously with a third in the bell, productivity might be doubled; certain tasks, difficult for a single diver could more readily be accomplished. Another possibility might be to use two four-man saturation teams, each assigned two saturation periods of 6 days each alternating, so that a total of 24 out of 30 working days would be spent on the site. The resultant surface interval between periods would give divers and archaeological staff the opportunity to discuss work to date more productively; this interaction and the possibility of following the progress of the excavation as seen on the surface would

greatly enhance divers' effectiveness in their second saturation period.

5. Visual monitoring of the excavation. A pan-and-tilt TV system, operated by remote control, would be invaluable. High quality closed-circuit helmet television would be still more effective, but prohibitively expensive.

Other problems can be overcome by the improvement or modification of aids used in 1977: a heavier, more rigid grid over the wreck would allow divers to support themselves more easily so as not to damage the site; a more rigid support for photo towers, and the use of an underwater Polaroid camera, would enhance photographic documentation; some type of sand dam could prevent the constant flow of sand from upslope; a method of positioning the Robertina observation bell would make it more useful; and more extensive chamber debriefing sessions would be helpful.

The question must also be raised as to whether or not the hull remains at the Secca di Capistello warrant recovery and conservation. The work by Michael Katzev at Kyrenia, which is a landmark, has shown this to be both a costly and time consuming process. One must also bear in mind that the Kyrenia wreck was only 30 m deep, easily accessible by prolonged SCUBA dives to Katzev and his experienced team of excavators.

The 1977 campaign on the Capistello wreck represented a unique attempt to combine saturation diving and archaeology. With the valuable experience we now have behind us, we look forward to the opportunity to return to the site, both to continue the excavation and to raise the standard of deep-water archaeology to the level we feel possible.

Acknowledgements

We would like to express our gratitude to the Soprintendenza alle Antichita della Sicilia Orientale, with whose permission the Secca di Capistello Shipwreck was excavated. We are particularly grateful to Dott. Paola Pelagatti, Primo Dirigente, Soprintendente Archeologico, Siracusa who granted us official permission. Also deserving our great thanks are Prof. Luigi Bernabo Brea, Emeritus Soprintendente alle Antichità della Sicilia Orientale, and Dott. Madeleine Cavalier, Conservatrice onoraria del Museo Archeologico Eoliano, who provided us with invaluable assistance and advice on Lipari. The excavation was conducted under the auspices of the American Institute of Nautical Archaeology in conjunction with Sub Sea Oil Services of Milan, and was directed by Dr Donald A. Frey with the assistance of Donald H. Keith who was in charge of archaeology and Faith Hentschel who catalogued the finds. Sub Sea Oil Services provided us with MN *Corsair*, under the command of Captain Franco Rizzi; and a team of saturation diving trainees under the direction of Comm. Ilio Lupolli. To these men, and to Ing. Giunio Santi, President of SSOS, we must extend our most profound gratitude, for without them the excavation would not have been possible. Through the extraordinary generosity and co-operation of these individuals a unique combination of industrial and archaeological skills permitted the excavation of an ancient ship lying at a depth previously inaccessible.

Notes

[1] Four different stamp dies were identified on the amphoras recovered during the 1976 survey. There were four examples of ΒΙΩ, three examples of ΧΑΡΗΣ in retrograde, and one each of ΓΑΡΗ and ΕΨΞΜ. In addition there were three stamps which were illegible (Katzev, 1976: 7). Of these, ΓΑΡΗ and ΒΙΩ are abbreviated forms, ΧΑΡΗΣ is self-explanatory, and ΕΨΞΕΜ (the last two letters of which are difficult to decipher) is probably a genitive of Ευεένω (Blanck, 1978: 96).

[2] These classifications have been made on the basis of Nino Lamboglia's, now somewhat controversial, preliminary classification of Campanian pottery (Lamboglia, 1952). The term Campanian is an unfortunate misnomer for a class of pottery which was also manufactured at centres outside Campania and widely distributed throughout the western Mediterranean.

[3] The stamps were generally made from a mould, into which the rosette was cut in intaglio. Once the stamp was removed from the mould it was trimmed and given any necessary finishing touches before being applied to a series of bowls. Any number of stamps might be produced from the same mould without being identical because of differences in the trimming processes (Corbett, 1955).

[4] Rosettes are omnipresent, but a relatively unusual quality in our rosettes should be noted. The contour of the stamp is not absolutely circular but is inflected slightly around each petal. A good parallel, but with eight petals, is found in number 104 from the Roman Forum (Morel, 1965).

[5] Campanian black-glazed pottery has been excavated from the following shipwrecks: Grand Congloué, Albenga, Dramont, Titan, Pegli, Spargi, and Gianutri, among others.

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Archéologie en eau profonde. Les fouilles de l'épave du Capistello, Lipari, îles Eoliennes

D. FREY, F. D. HENTSCHEL AND D. H. KEITH

Cette note concerne la fouille d'une épave du 3ème siècle av. J.-C. coulée sur les récifs de Capistello, près de Lipari, l'une des îles Eoliennes située à 50 milles au nord-ouest du détroit de Messine. La fouille fût executée pas 60 mètres de fond par l'Institut d'Archéologie navale avec des professionnels de la plongée à saturation de la Sub Sea Oil Services de Milan. La cargaison comprenait des amphores dont 33 avec des estampilles et de la céramique campanienne très fine. Quelques fragments de la coque furent aussi trouvés. Les diverses méthodes utilisées furent comparées entre elles, où l'on put mettre en évidence la superiorité du sous-marin par rapport à la cloche à plongée pour le contrôle et l'enregistrement des données et celle des tourelles-photo transportables et rigides sur les appareils simplement tenu à la main pour l'exécution de mosaïques photographiques.

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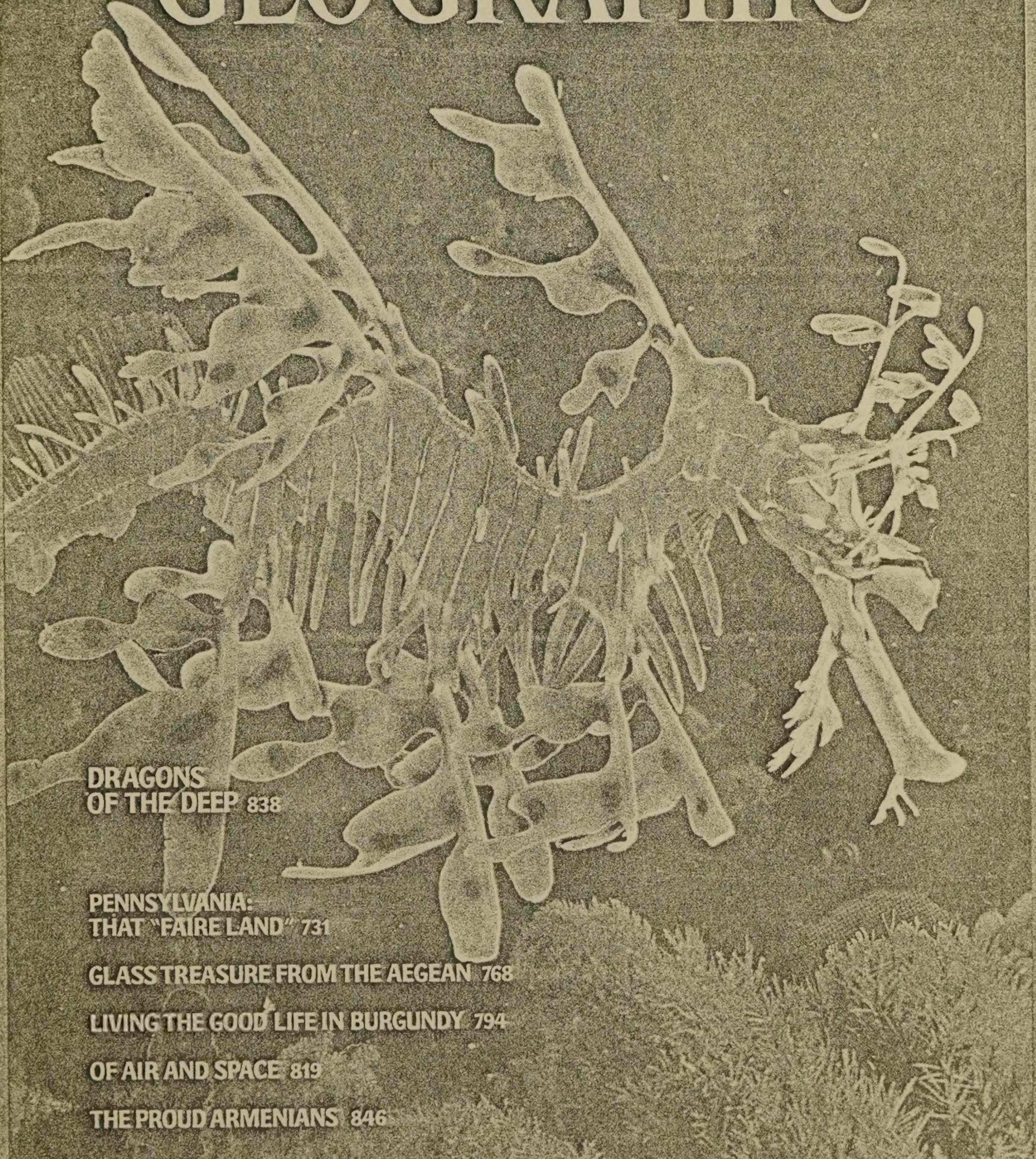

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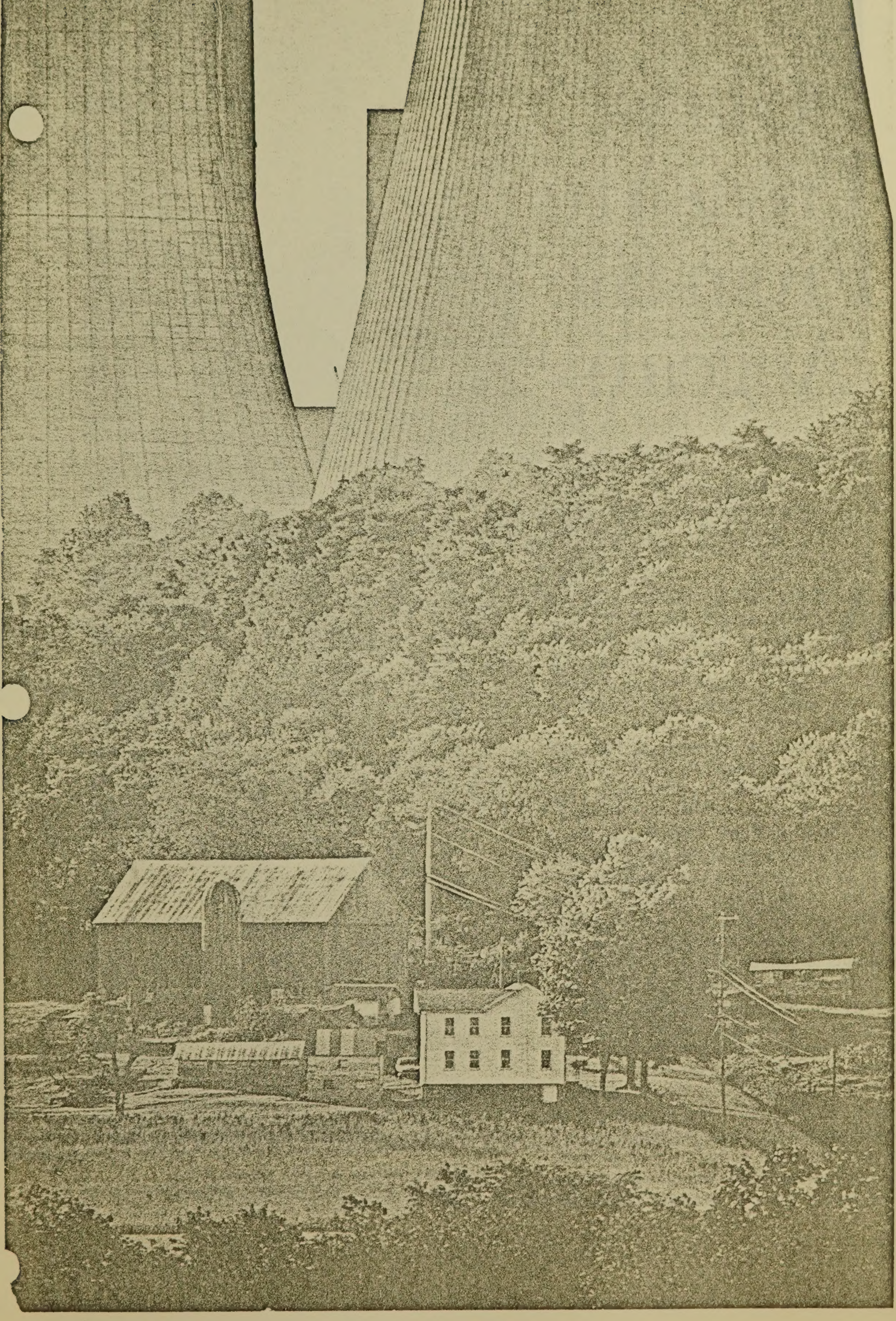


Glass Treasure From the Aegean

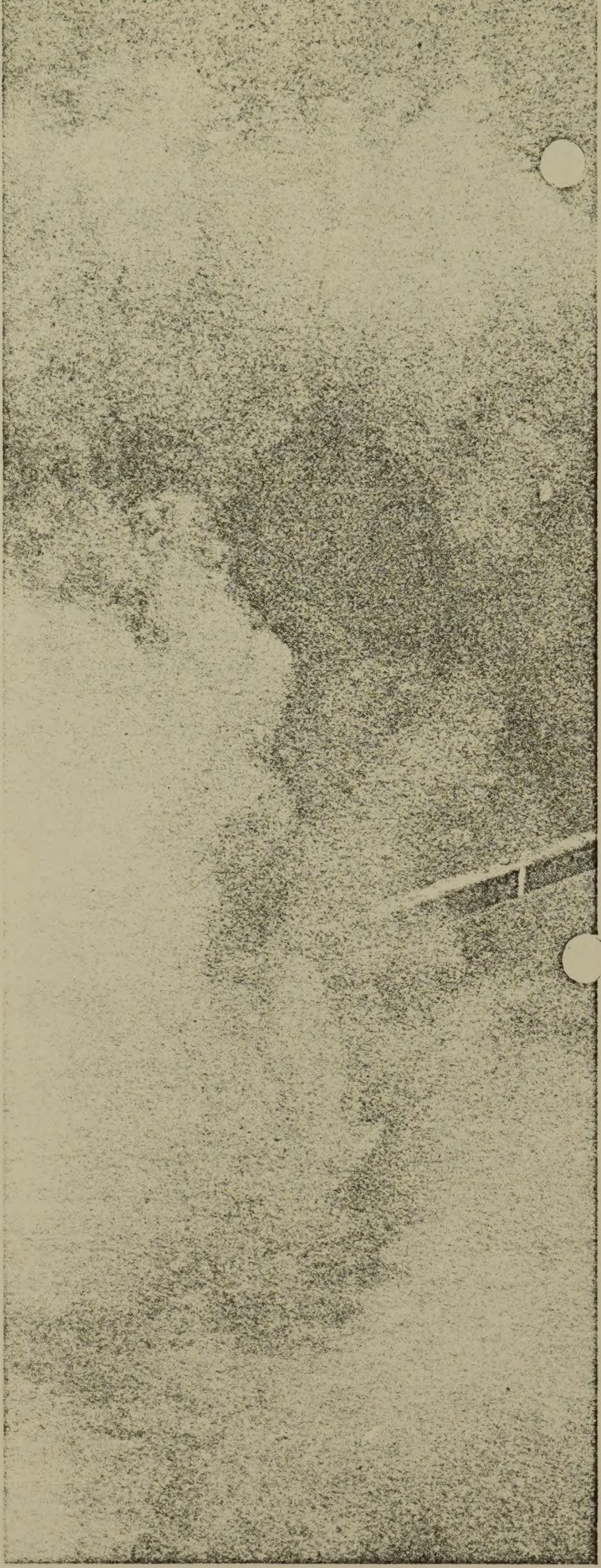
By GEORGE F. BASS, Ph.D.

Photographs by
JONATHAN BLAIR

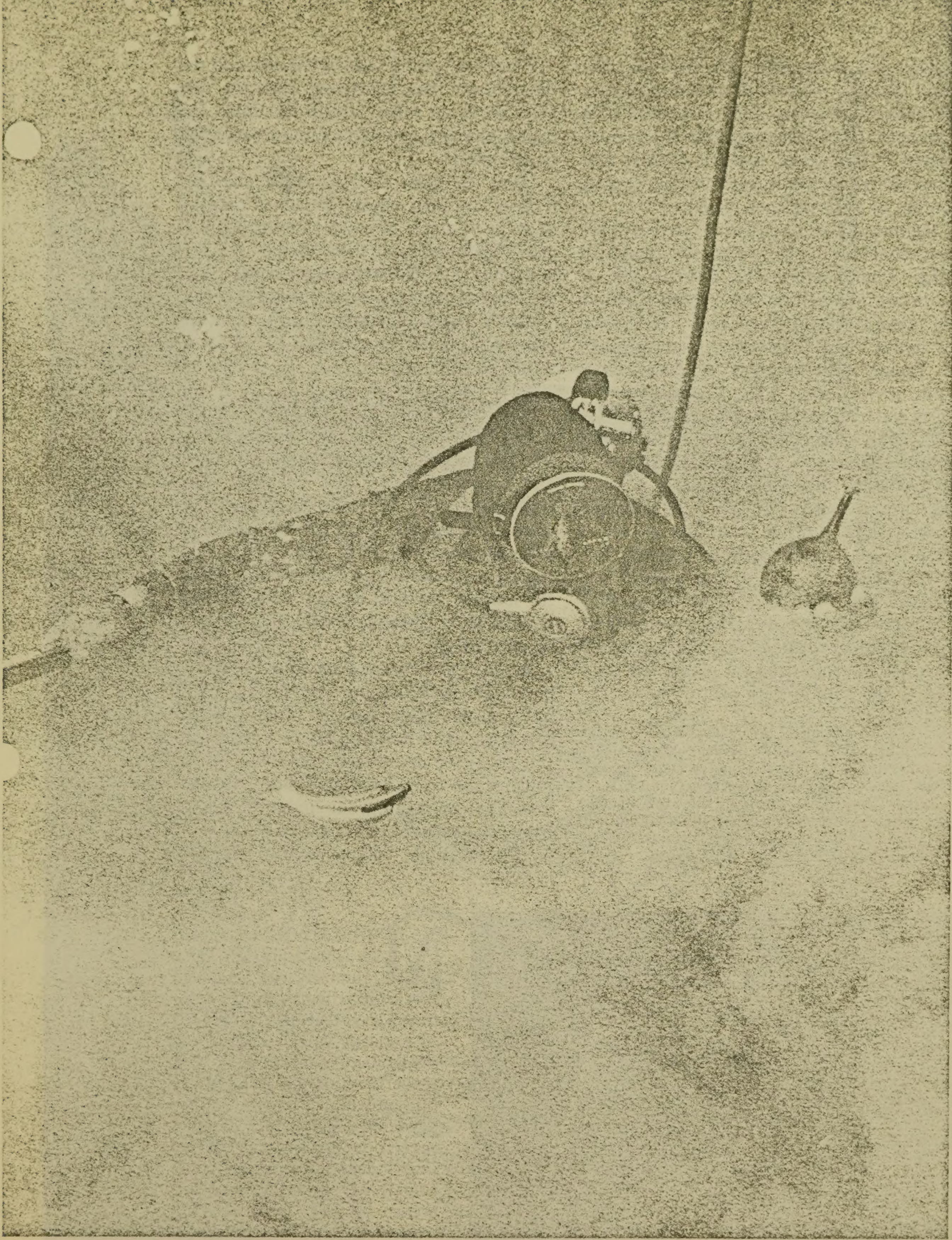
WEDGED into the base of a great submarine ridge, the chunk of glass shone dimly in the half-light at 110 feet. As I reached to pull it free, my finger spurted a small plume of green blood, its familiar red color filtered out by the depths.

In the excitement of discovery I scarcely noticed the cut; during the weeks that followed, such wounds would become commonplace. Each time my diving partners or I cut a hand or finger while exploring the bottom of that small harbor on the Aegean Sea, we were rewarded with another masterpiece of the ancient glassworker's art. More important still, we were rewarded with priceless new knowledge of man's early attempts to conquer the sea.

In this case the sea had conquered man, though we do not yet know how. During that first dive I was not even certain that the remains of a ship lay beneath me. I had been shown the site four years earlier by a retired Turkish sponge diver named Mehmet Aşkın. At that time I was surveying Turkey's coastline for significant early wrecks, a project organized by our Institute of Nautical Archaeology and financed with National Geographic Society research funds. My



Clouds of silt rise as a diver flippers along a metal mapping grid with a bulbous bottle



just plucked from the sea's treasury. Here, off Turkey's Aegean coast, archeologists are reaping a bonanza in medieval glass from a 1,000-year-old shipwreck.

partner and co-founder of the institute, Michael Katzev, meanwhile was conducting his brilliant recovery and restoration of a 2,300-year-old Greek cargo ship at Kyrenia, Cyprus.* The vessel, reconstructed in Kyrenia's Crusader castle, survived the Cyprus conflict of 1974 without mishap.

Mehmet Aşkın had guided me in a chartered boat to a remote anchorage known as Serçe Limanı—Sparrow Harbor—off a peninsula jutting into the Aegean north of the island of Rhodes (map, page 772). There my friend Yüksel Eğdemir, a commissioner of Turkey's Department of Antiquities, made several dives while I remained confined aboard the boat with a cold.

"There's glass everywhere down below," Yüksel announced, surfacing from the first dive with a rainbow of brightly colored shards in his hands. "You can't fan away the sand without cutting your fingers. It's a good site, George, a really good one."

Subsequent dives turned up several amphorae, large clay jars used to carry oil or wine. Their shape and character suggested a date in the Byzantine period of Turkish history. After examination I estimated their date in the 12th or 13th century A.D.

I made a careful note of the site and the discoveries, then continued with my survey. Work on other wrecks occupied the next four years, but Serçe Limanı remained in my mind.

Were the glass and the amphorae that Yüksel had seen simply jettisoned cargo—perhaps by some long-ago captain? Or was an actual wreck lying there? Serçe Limani is notorious for its treacherous winds, and there are several known wrecks in the area. Yüksel's discoveries might represent yet another sinking. In the spring of 1977 I determined to find out.

Undersea Detective Work a Gamble . . .

With Turkish Government approval I assembled a team of 20 outstanding Turkish and American divers and scientists. Last June we set off from the Turkish port of Bodrum with another good friend, fisherman Mehmet Turguttekin, in three small boats. Anchoring our wooden diving barge inside the harbor, we built a camp ashore sturdy enough to withstand Serçe Limanı's ferocious winds.

My discovery of the glass chunk occurred on my first dive, in company with Oğuz Alpözen, also a commissioner from Turkey's Department of Antiquities. In addition to the glass, we uncovered amphorae, seemingly of the type I had dated four years earlier. Though exciting, the finds still did not prove the existence of a wreck.

"Do you think *(Continued on page 774)*

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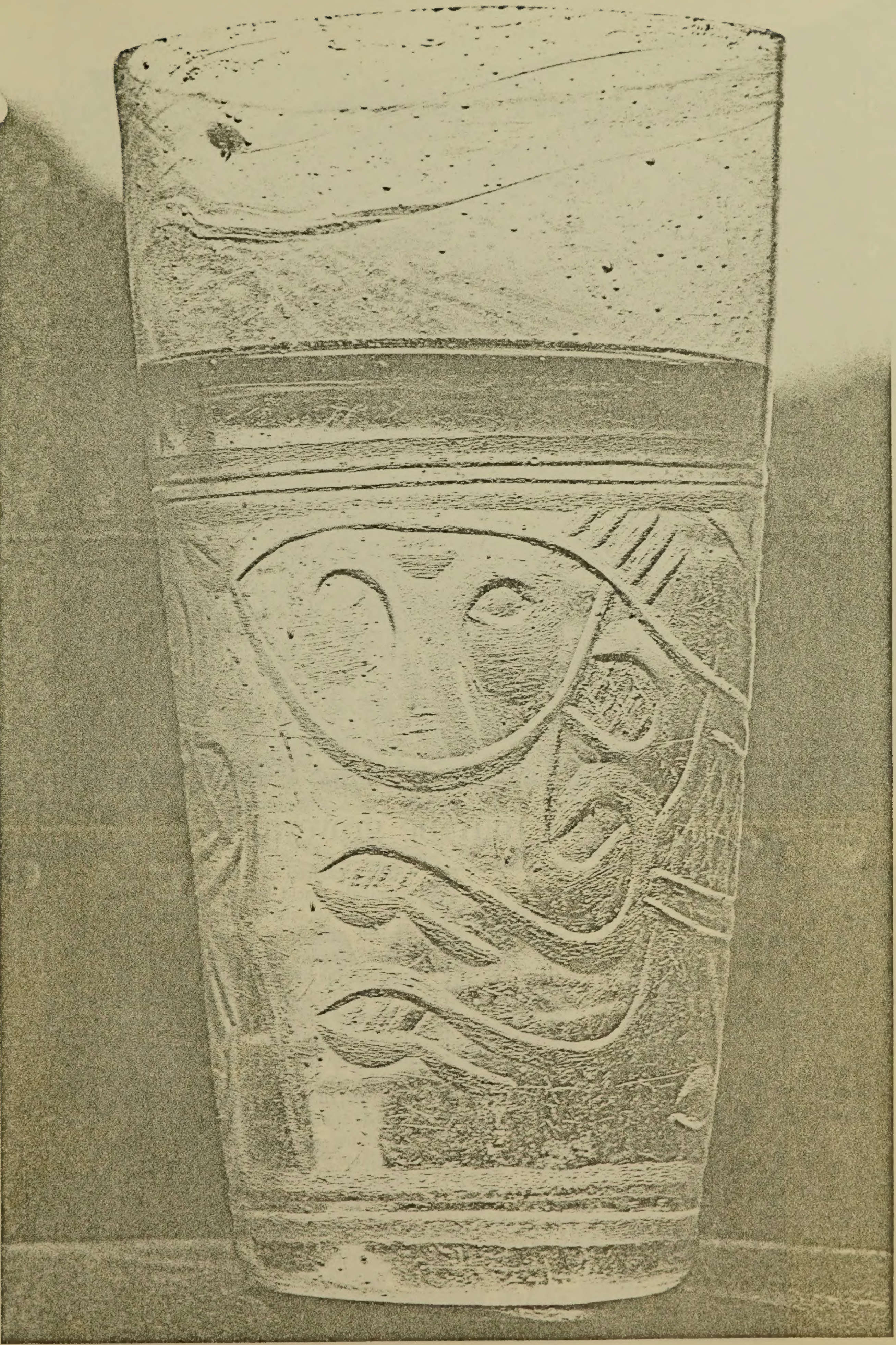
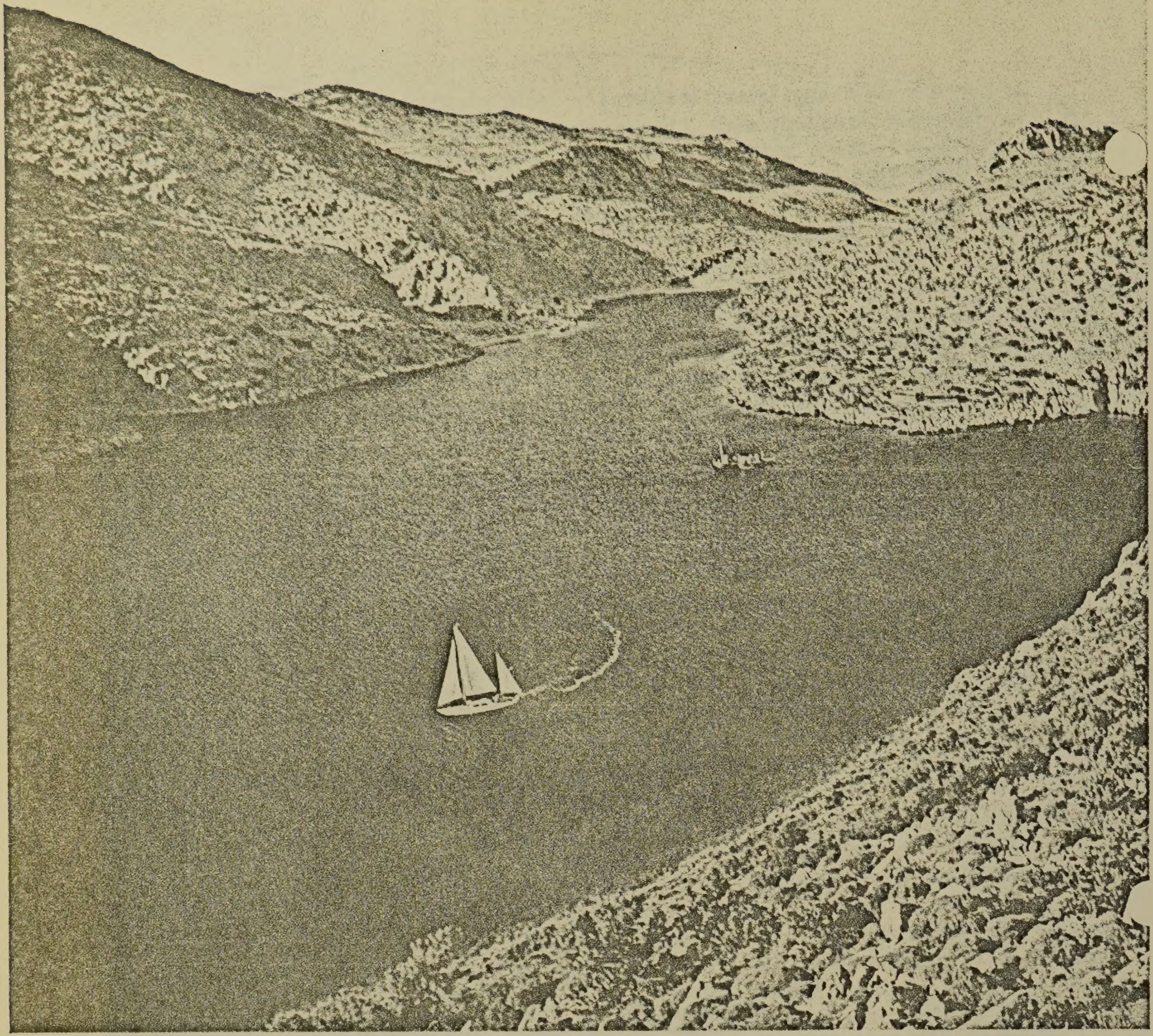
*See "Last Harbor for the Oldest Ship," by Susan W. and Michael L. Katzev, in the November 1974 GEOGRAPHIC, and "Resurrecting the Oldest Known Greek Ship," by Michael L. Katzev, June 1970.

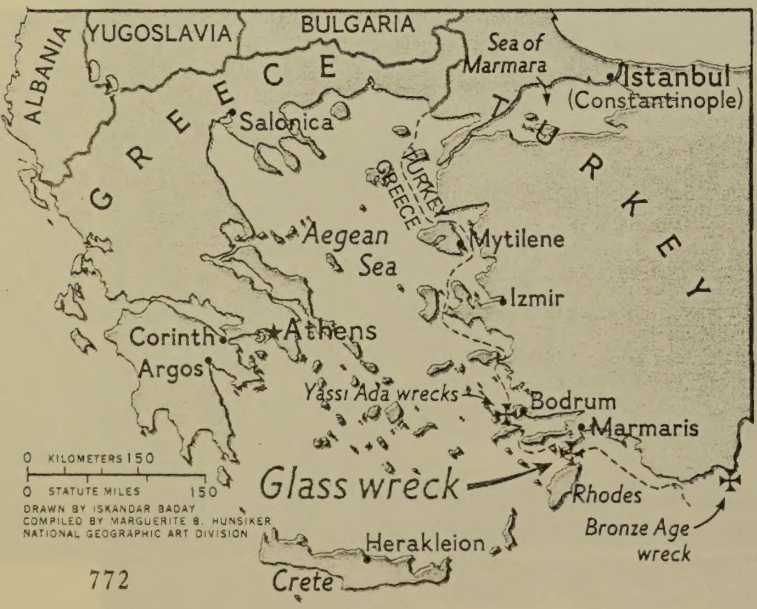
Author George Bass, who has written two previous GEOGRAPHIC articles (September 1968 and July 1963) and produced four books, is professor of anthropology and geography at Texas A & M University.

MIRACULOUSLY intact, a delicate cup (**left**) and a tumbler with engraved Picasso-like lions (**right**) come from a trove that has so far yielded 30 exquisite vessels of glass—all resembling in decoration and shape those of the 11th-century Muslim world. Fragments of finished ware and chunks of cullet suggest the cargo of the ship was largely glass. Though presumably Islamic, her nationality is still uncertain because Greek-inscribed amphorae and coins also recovered point to ties with the Christian Byzantine Empire.





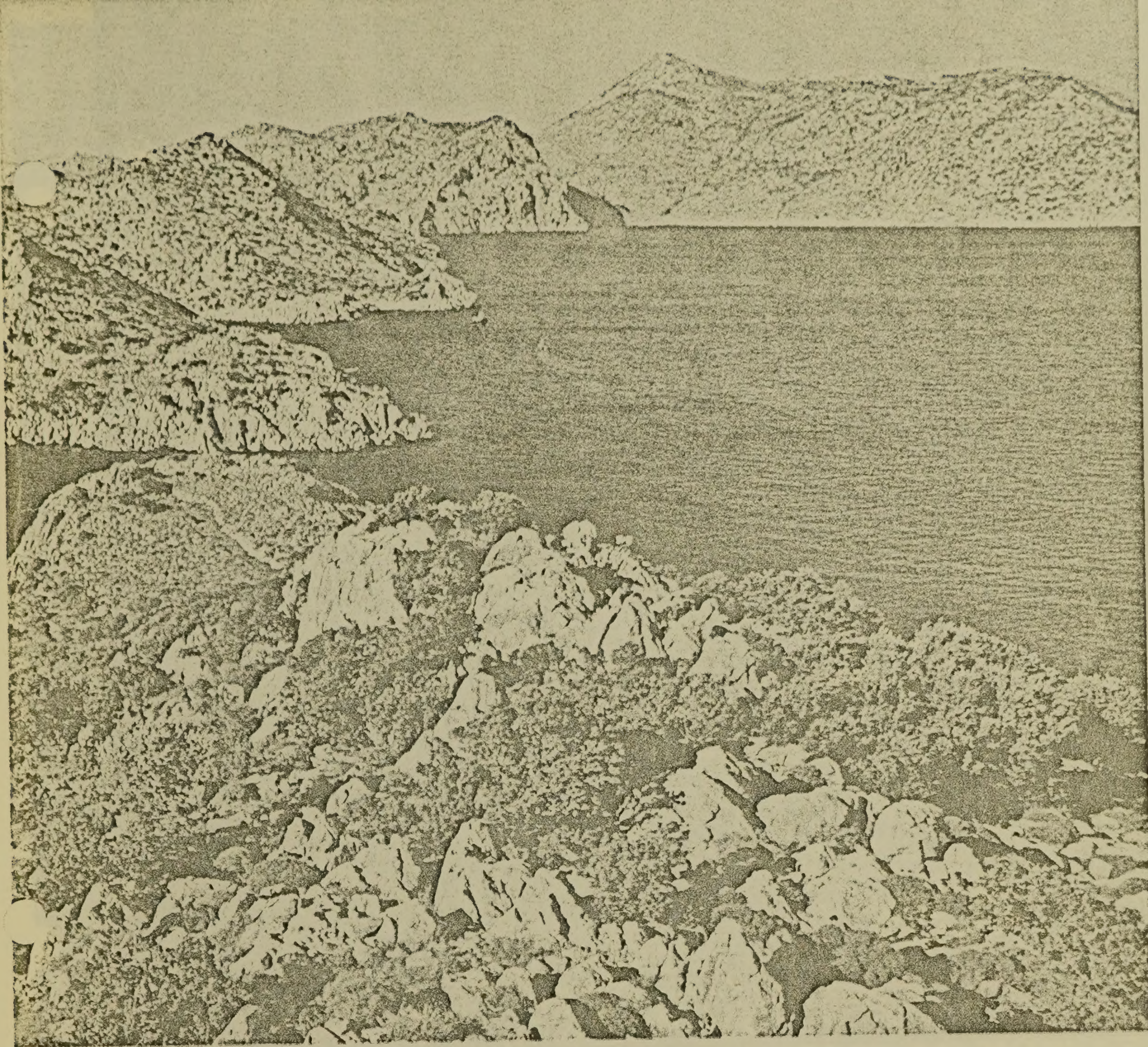
Turkey's marine graveyards


ALBANIA
YUGOSLAVIA
BULGARIA
Sea of Marmara
Istanbul
(Constantinople)
GREECE
Salonica
TURKEY
TURKEY
GREECE
Aegean Sea
Mytilene
Izmir
Corinth
Athens
Argos
Yassı Ada wrecks
Bodrum
Marmaris
0 KILOMETERS 150
0 STATUTE MILES 150
Glass wreck
Rhodes
Bronze Age wreck
Herakleion
Crete

DRAWN BY ISKANDAR BADAY
COMPILED BY MARGUERITE B. HUNSIKER
NATIONAL GEOGRAPHIC ART DIVISION

Often a caldron of savage winds, the seemingly placid harbor of Serçe Limanı (**above**, left) lured more than one ancient ship to its death. The "glass wreck" lies 110 feet under the diving barge in the background.

No stranger to these waters, expedition leader and author Dr. George Bass (**right**, in light-blue shirt) breaks for lunch with his team, mostly Turkish scholars and students. Over the years Dr. Bass and his associates have pioneered many underwater-excavation techniques. At nearby Yassı Ada they excavated Roman and Byzantine wrecks dating from the fourth and seventh centuries, and off southern Turkey a 3,000-year-old Bronze Age ship.



there's really one down there?" I asked Oğuz after we had surfaced and returned to the diving barge.

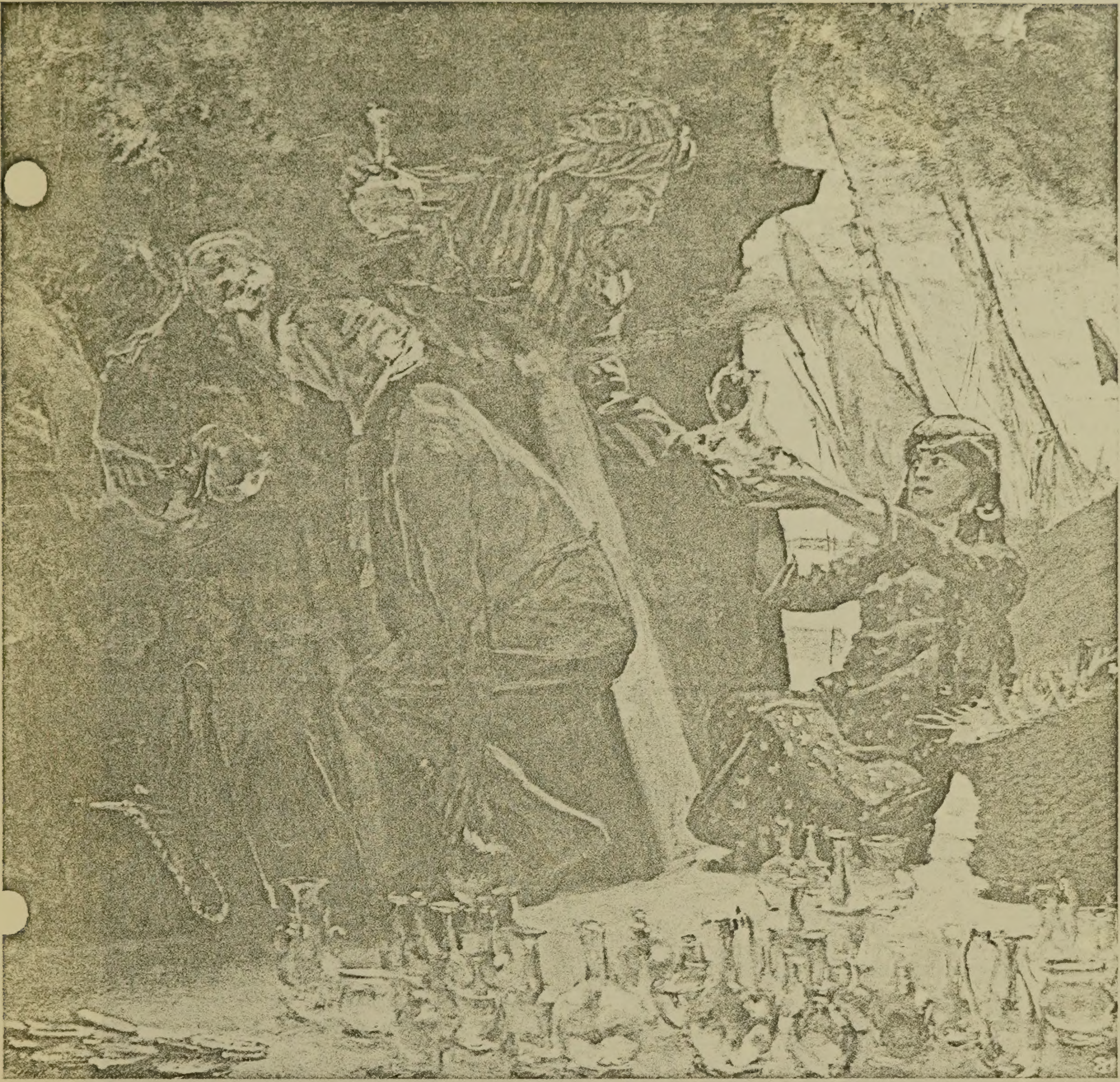
"İnşallah," he answered with a quizzical smile. "As God wills."

I could only second the wish. Archeology is always a gamble, and I was gambling heavily at Serçe Limanı. The cost of such an expedition, with diving gear, compressors, a recompression chamber for possible cases of the bends, plus food and other equipment for 20 people, is sizable.

To finance the project, I had staked funds not only from our Institute of Nautical Archaeology but also from Texas A & M University—the institute's headquarters—from the Corning Glass Works Foundation, and from the National Geographic Society. Unless we found a ship along with the glass and the amphorae, the funds could be wasted.

. . . And the Gamble Pays Off

My concern proved to be short-lived; on the very next dive the gamble paid off. Following Oğuz's and my initial exploration, two longtime colleagues, Dr. Frederick van Doorninck of Texas A & M and Robin Piercy of the institute, went down to continue the search. Within twenty minutes—the limit we had set for dives with minimum decompression on the way up—the two men surfaced with an air of excitement that I have



PAINTING BY STANLEY MELTZOFF

FROM SODA, sand, and raw-glass cullet comes an array of glassware in this re-creation of a medieval Islamic glassworks. While his son stokes the firing chamber, a master glassblower moves through four major production stages, from left to right. First he inflates a gather of molten glass with his blowpipe, then shapes the bottom on a flat stone. After transferring the bulb to a metal rod and reheating it, he opens the mouth with a wooden tool. Finally he places the vessel in an annealing oven, where it may stay overnight, attended by an assistant. His wife, at right, packs selections of glassware for a sea-trading merchant.

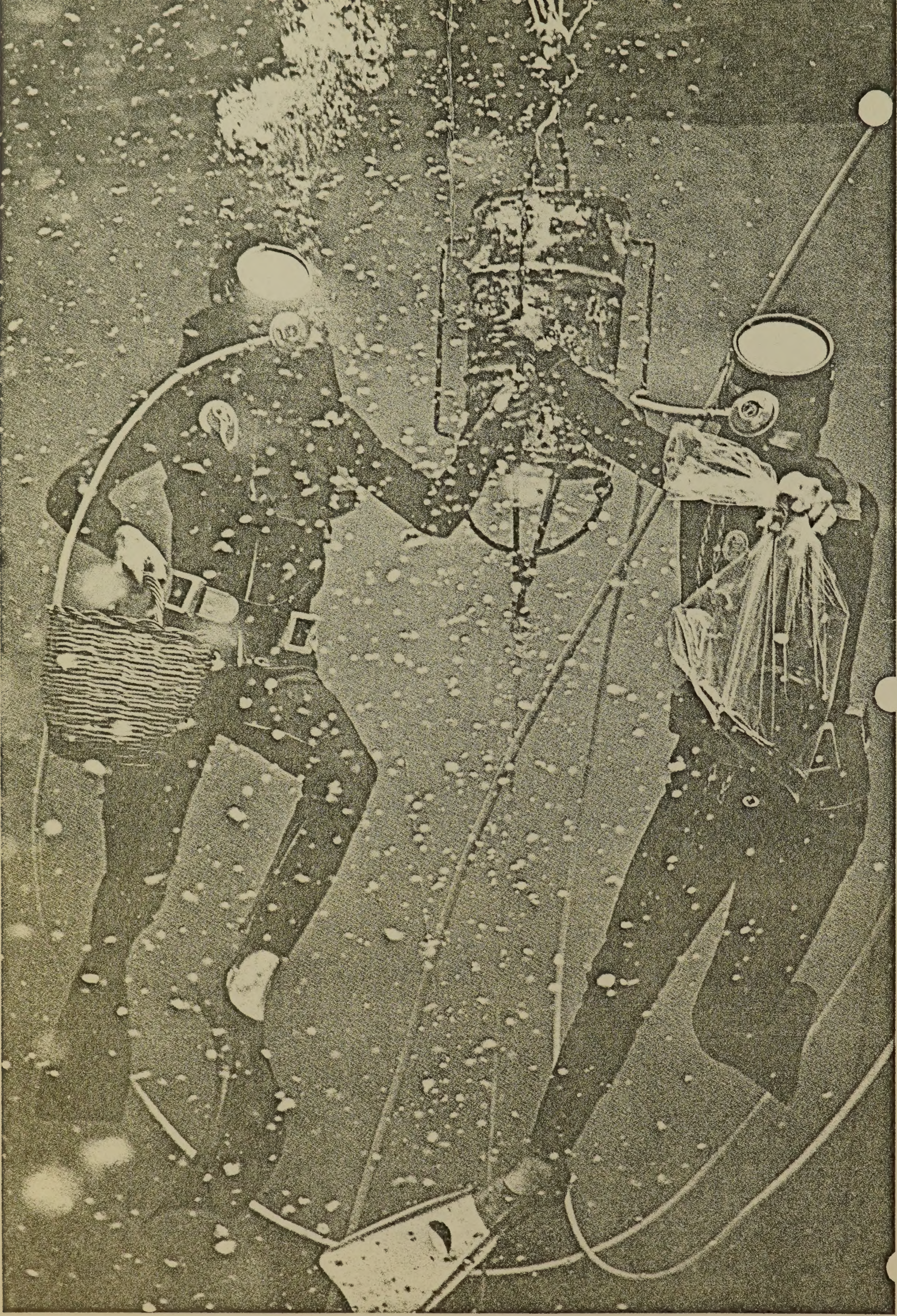
rarely seen in all my 17 years of underwater archeology.

"It's there, the ship's there!" Fred announced triumphantly as he and Robin clambered back aboard the barge. "At first we couldn't see anything but sand; then our eyes adjusted, and we made out several amphorae and a lump or two of glass.

"But still no ship, until the very end of the dive. Then suddenly there it was, almost as if it had materialized from empty sand—the definite lines of a hull."

As Fred talked, Robin had been sketching in a notebook, and at length he held it up.

"The bow is here," he said, indicating a spot with his pencil, "and just beyond it is a



pile of what appear to be iron anchors. Then there's a mass of ballast stones and more amphorae. The stern is here, and in between there's an immense amount of glass."

I was astonished at the sketch, not only for its detail but also for what it revealed from a single dive. I recalled the time I had worked with a full diving crew on a Roman wreck elsewhere in Turkey; it took three months before we even knew which end of the ship was which.

"Telephone Booth" Aids Search

With our target firmly located, we spent the next few days shifting the barge to a point directly overhead and readying our equipment for underwater excavation. One of the most important items was our "telephone booth," a Plexiglas dome that could be lowered to the seafloor and secured with weights. The dome was equipped with a telephone line and compressed-air hoses running to the surface, so as many as four divers could stand inside, dry from the chest up, breathing fresh air.

Next we laid out a metal grid across the bottom over what we expected would be the area of the wreck. With the grid as a reference we could then map the entire site, pinpointing each item as it was removed.

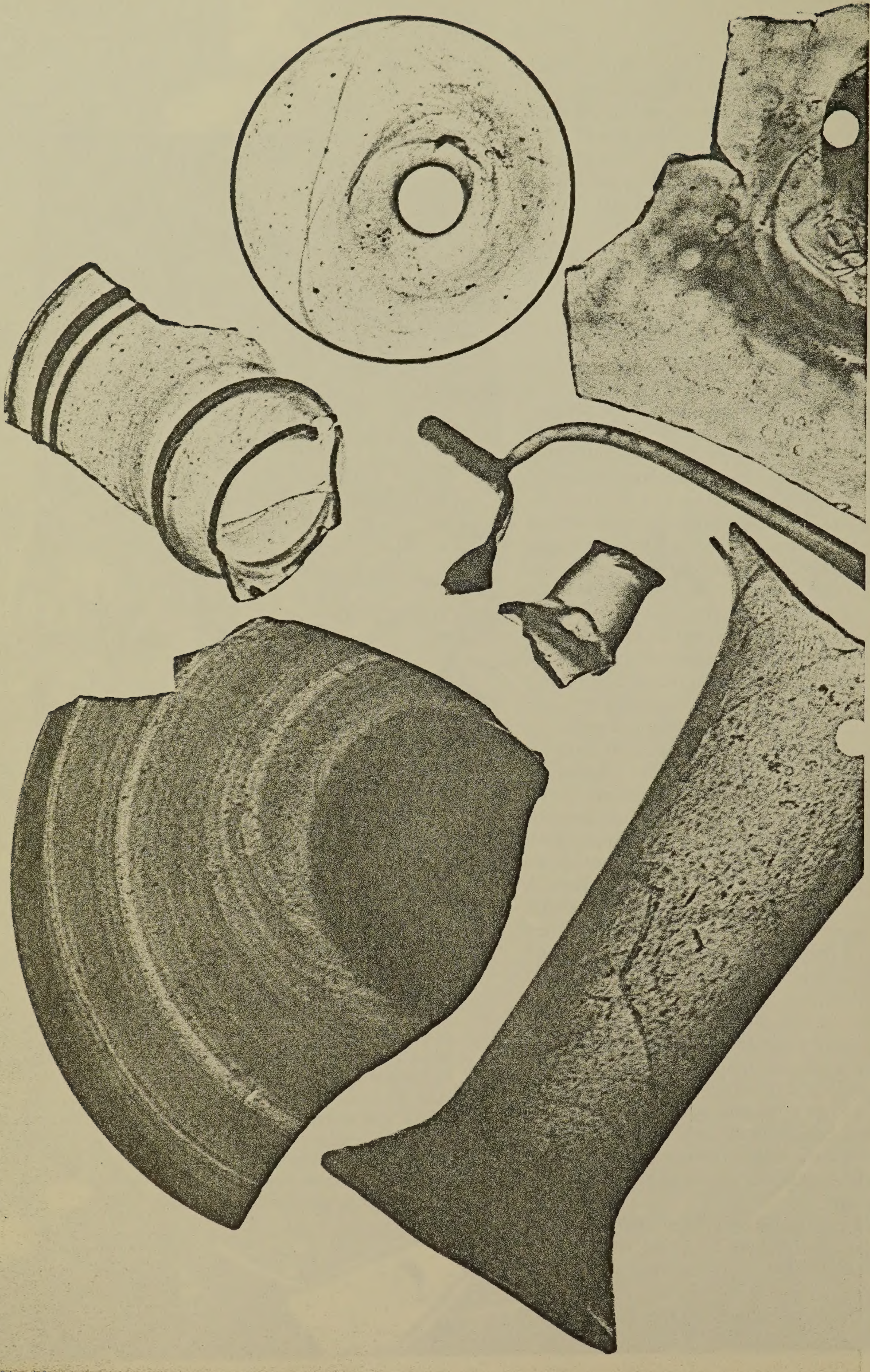
For the initial reconnaissance of Serçe Limanı I had taken only half the team of 20, and now the others joined us: my friend Yüksel Eğdemir; Gündüz Gölönü, an artist and professor from the Istanbul State Academy of Fine Arts; several members of our institute staff; and a group of young Turkish divers from Istanbul's Bosporus University, formerly known as Robert College. We were later joined for a brief time by my old friend Jack Kelley, chairman of the board of our institute.

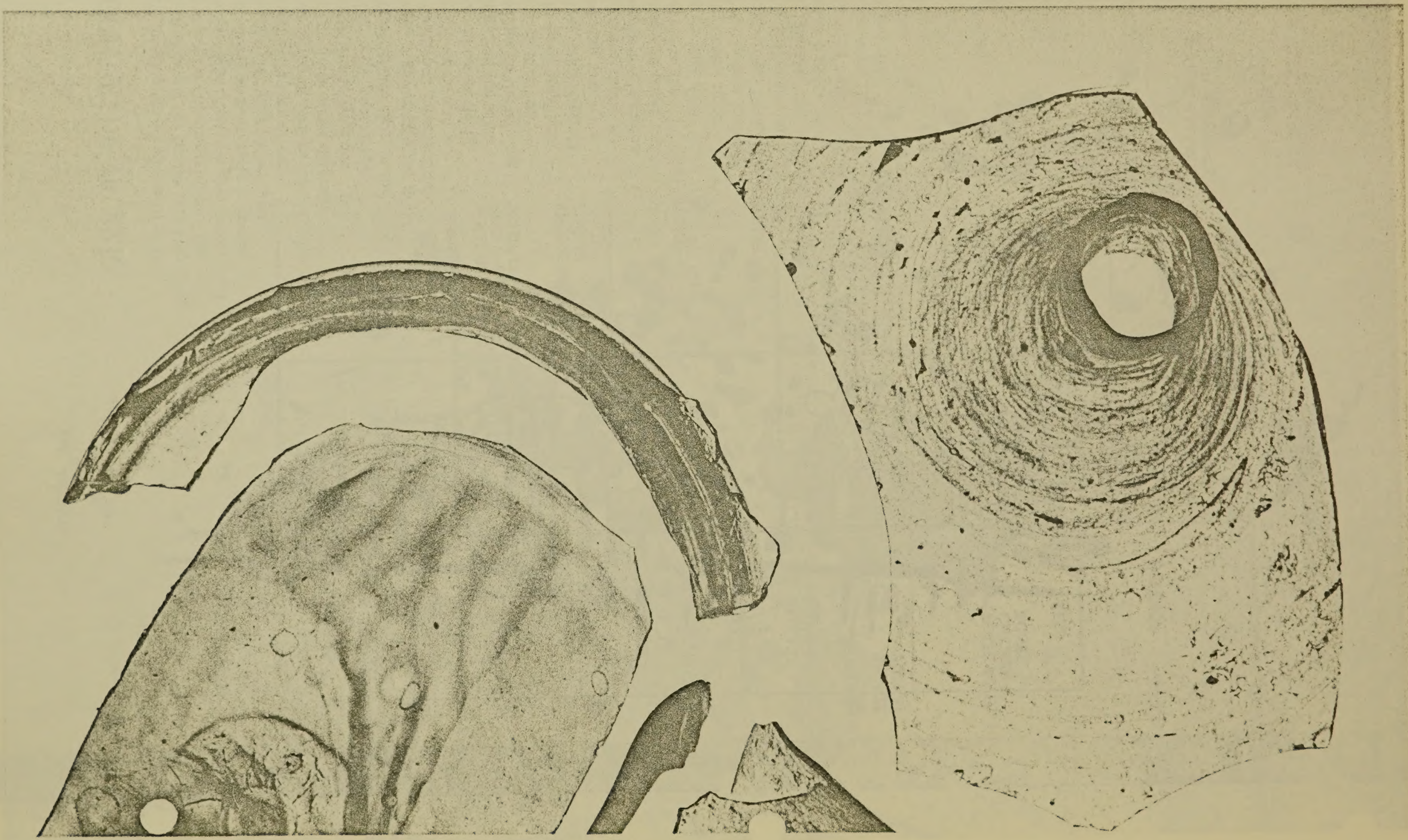
On my next dive I uncovered an exquisite sample of what the wreck was soon to yield. Gently excavating sand in my assigned area of the grid, I encountered the base of what I took to be a broken bottle, buried several inches below the surface. So far in our brief surveys we had seen only shards of glass, evidence that our ship may have met a violent end.

As I probed deeper, I expected to find jagged edges, but none appeared. At length the bottle lay fully (Continued on page 786)

PENDING EVICTION from his home in an old amphora, a meddlesome octopus nicknamed Fred became something of a team mascot, despite his habit of grabbing things from the divers. Here Dr. Frederick van Doorninck retrieves a fragment from the creature he discovered (above).

Strewn throughout the wreckage, thousands of glass shards had to be pried from the seabed. As a result, divers suffered cut and bleeding fingers. But a greater hazard in these 110-foot depths was the bends—an often crippling, sometimes fatal malady brought on by too rapid a decrease in pressure. To avoid it, two divers on their way to the top with a morning's bounty (facing page) pause at a decompression stop ten feet under the barge. They gulp air from hoses lowered from above as they pass regular breathing gear to the next shift.





Piecing the puzzle

A little imagination—and a turn of this page—will reveal the profile of a ship lying on its side in a drawing (right) of the wreck site. Under an iron grid constructed by the author and his party to enable the precise plotting of every find, the wreckage sweeps from curving sternpost to forward stem. The diver in the diagram corresponds exactly to one hovering in the photograph (overleaf). Below him, in the hold area, a glittering array of glass fragments, representing nearly 200 forms and a rainbow of colors (left), was dug from the sand. Downslope, to the left and above deck level, an assortment of amphorae and other items suggests that the ship may have had a topside cabin. As the vessel's configuration took shape on paper, it appeared to the excavators that they may have come upon one of the earliest known "modern" ships. Unlike Greek and Roman ships of early vintage, this craft apparently had its hull planking built on a framework of keel and ribs, rather than the reverse.

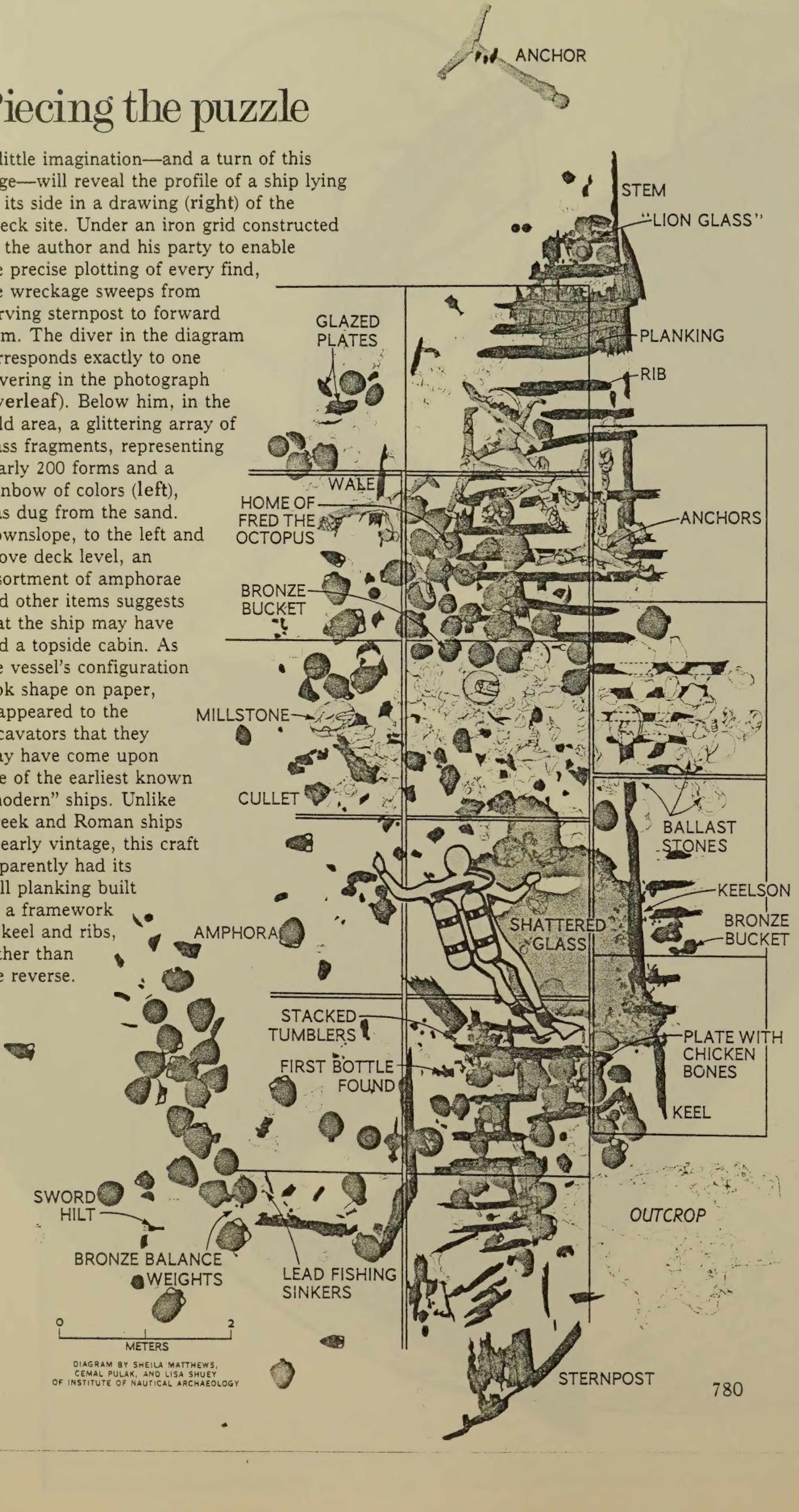
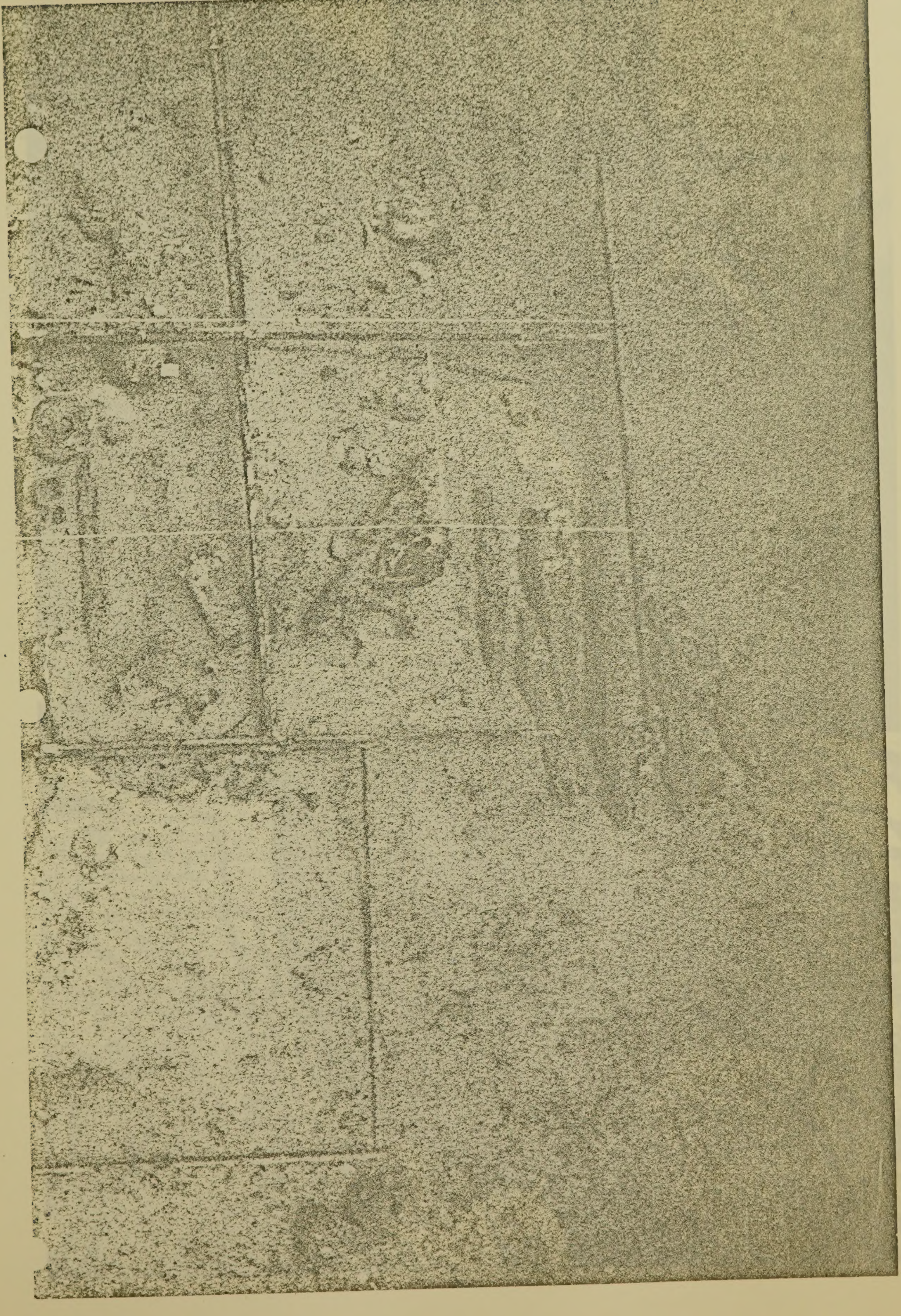
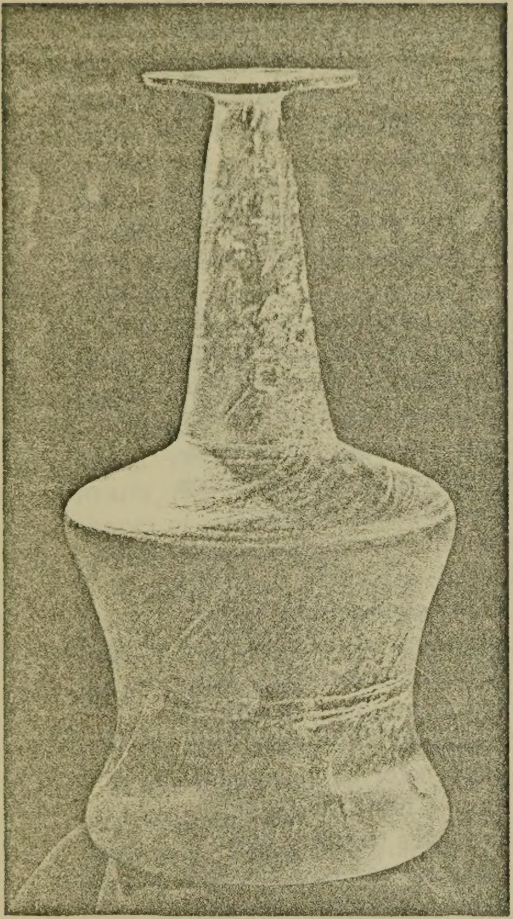
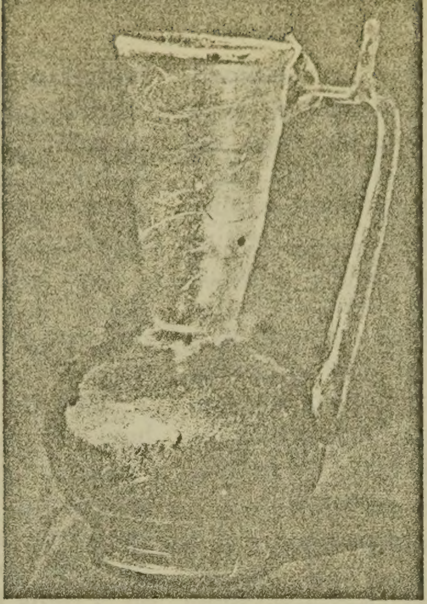

ANCHOR
STEM
"LION GLASS"
GLAZED PLATES
PLANKING
RIB
WALE
HOME OF FRED THE OCTOPUS
ANCHORS
BRONZE BUCKET
MILLSTONE
CULLET
BALLAST STONES
KEELSON
SHATTERED GLASS
BRONZE BUCKET
AMPHORA
STACKED TUMBLERS
PLATE WITH CHICKEN BONES
FIRST BOTTLE FOUND
KEEL
SWORD HILT
OUTCROP
BRONZE BALANCE WEIGHTS
LEAD FISHING SINKERS
0
2
METERS
STERNPOST

DIAGRAM BY SHEILA MATTHEWS, CEMAL PULAK, AND LISA SHUEY OF INSTITUTE OF NAUTICAL ARCHAEOLOGY

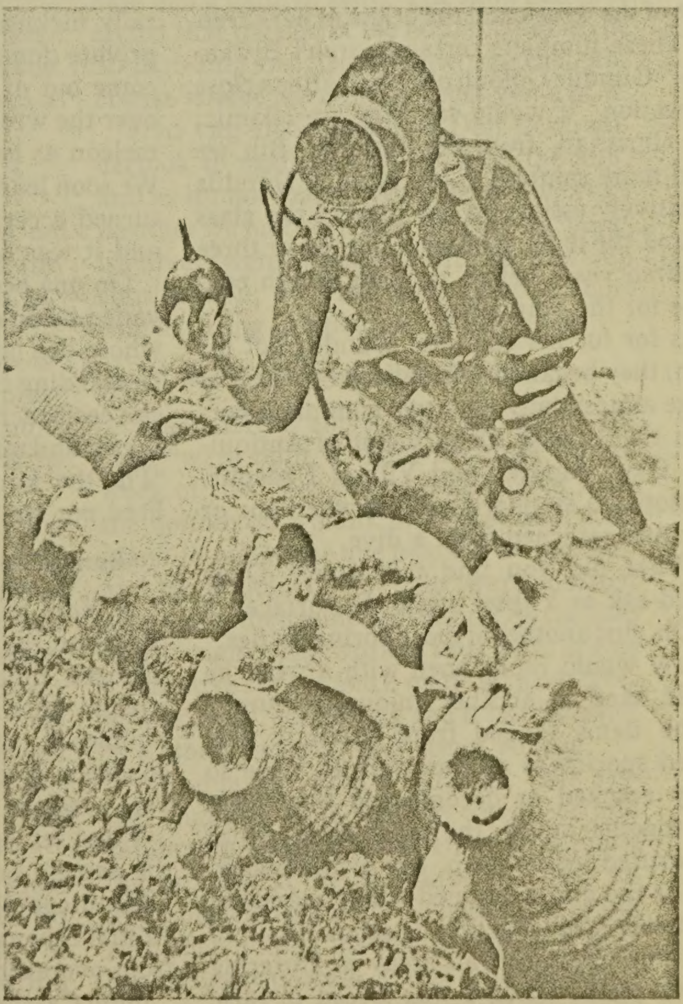






HARDENED BY AGES of interaction with the corroding glass, seabed sediment in a clear-glass pitcher (left) and a jug (right, top) may require weeks of patient effort for removal. Many objects had deteriorated so badly that only the impacted silt held them together, but others —like this pinched-waist bottle (above)— seemed to have suffered little.

Though the art of fine glassmaking all but died out in Europe after the fall of the Roman Empire, it was kept alive and enriched by Muslim artisans before revival in Venice in the 13th century. But where in that vast Islamic world stretching from Spain to central Asia these masterpieces were produced remains a mystery. Chemical analysis may reveal, if not the regional origins of the objects, at least whether they were all manufactured by the same glassworks.



Byzantine connection: Used for carrying oil or wine, the ship's numerous amphorae (above) were Byzantine Greek. Bottles in the diver's hands, however, resemble those fashioned by Muslim craftsmen.

(Continued from page 777) exposed, miraculously unbroken. It was a lovely piece of work, rounded at the base and pinched at the sides in an hourglass effect.

Not until Robin Piercy had photographed the bottle did I lift it gingerly from its resting place, only to find an even greater treasure underneath. In the small crater left by the bottle lay nested clear-glass tumblers, each paper thin and engraved with gracefully swirling patterns. Whether or not our ship had died violently, it is a miracle that the tumblers survived the plunge to the bottom and the eventual collapse of the hull.

Discovery Rate Picks Up

That first discovery set off a summer-long debate among members of our team over the date of the wreck and the origin of her cargo.

"These tumblers certainly aren't Byzantine," Gündüz Gölönü observed after a close inspection. "I would say they are Islamic, not Christian, from the patterns. But we need more samples to be certain." Gündüz tentatively estimated the date of the glass around the tenth century A.D., two or three hundred years before my own rough estimate for the amphorae.

As for further samples, Gündüz got his wish; they began to come aboard the diving barge almost daily. Our two commissioners from the Turkish Department of Antiquities, Oğuz Alpözen and Yüksel Eğdemir, developed a standard routine when one or the other returned from a dive.

"What did you find this time?" Oğuz would ask as Yüksel broke the surface.

"Oh, just another of those boring bottles," Yüksel would reply; then with a wink he would hand up another unique treasure.

The items ranged from perfectly preserved specimens of glassware to those so badly cracked or decomposed they were held together only by the impacted sand that had drifted inside them. My own assigned area of the grid contained whole masses of fragments fused together by sand and silt so that they resembled an array of glittering shark's teeth. Often I was forced to raise these lumps intact, to be painstakingly separated ashore with dental tools.

Despite the risk of cuts and infections, none of us wore gloves while diving. To an underwater archeologist touch is often as important as sight, especially when one is working amid a cloud of sand and silt stirred up from the bottom. Gradually we learned from experience how to avoid serious injury, but our hands always looked as if we were excavating a brier patch.

Fred van Doorninck had an additional obstacle in his area of the grid—a feisty octopus with a strong sense of territorial rights (page 777).

"He's living in an amphora up by the bow," Fred said after the first encounter. "He tried to pull the plastic labeling tags out of my hand." Then after another dive: "Now he's all over my camera so I can't shoot a single frame, and he's trying to pull my watch off. I think he considers us trespassers."

Eventually the octopus—whom we naturally nicknamed Fred—accepted us in his private domain. Oğuz even taught Fred to come out of the amphora and follow him over the wreck, changing colors like a chameleon as he glided from object to object. We soon learned, however, that when Fred turned a certain dark color he was angry, and it was best to give him a wide berth.

On one occasion Fred's territory was invaded by an even larger octopus, a monster whose den lay in some rocks above the site. Descending from its lair, it spread its tentacles easily across a two-meter section of metal grid and remained for a while, as if to say, "I'm the king of Serçe Limanı." Neither Fred nor we were inclined to argue.

Bends More Lethal Than Octopuses

A more subtle danger awaited unwary divers on the wreck. At a depth of 110 feet nitrogen quickly dissolves in the bloodstream, to be released in the form of deadly bubbles if a diver surfaces too rapidly. The condition is known as the bends, and a severe case can result in death.

I had set rigid diving schedules to avoid the danger, but once, after a dive, Gündüz Gölönü complained of an aching shoulder. At first I thought it was merely tired muscles from overexertion.

John Cassils, our team physician, thought otherwise. "Look," he said to me, "Gündüz's shoulder *may* just be strained, but it's possible that he has a touch of the bends. Let's slip him in the recompression chamber on oxygen and see if it helps."

John was right. Inside the chamber Gündüz was artificially returned to the pressure at sixty feet below the surface, and the pain in his shoulder disappeared. Slowly we returned him to pressure at sea level, so that the excess nitrogen in his blood escaped harmlessly. Fortunately for Gündüz, there were no lasting effects. The episode made even our veteran divers more cautious.

In thousands of dives we've made over the years, this was only the second case of the bends to occur, a record I am proud of.

Within the space of a few weeks we collected whole specimens or fragments of nearly two hundred different forms and shapes of glassware. The range and beauty of their colors dazzled us.

"If these were all made in the same glassworks," observed Don Keith, a colleague from the institute, "that glassblower had a lot of imagination."

Whence Came the Glass, and When?

Without chemical analysis, of course, no one could really answer Don's question; the glass might have come from a single works, from a small group of related factories, or from sources throughout the eastern Mediterranean. In medieval times, as in the present, artisans frequently traveled from country to country, taking their favorite patterns with them.

In many cases, however, the artisans themselves merely worked the raw glass produced by others. Among the ballast stones in the midship section of the wreck we discovered nearly half a ton of cullet—heavy chunks of glass such as the one I had first encountered, which were melted down by glassblowers to create a variety of products (pages 774-5). The cullet varied in color from blue and green to amber, often with swirling patterns resembling taffy.

"They were the raw material of the glass trade," explained Dr. Robert Brill, a world authority from the Corning Museum of Glass in Corning, New York, who paid a brief visit to Serçe Limanı. "One manufacturer of cullet might supply several glass factories, perhaps even in different countries. Chemical analysis should tell us whether the composition of your glassware and the cullet is identical. It might also tell the original source—Egypt, the Levant, or possibly even Persia—and whether a single glassworks produced the whole cargo."

To our treasury of glass we slowly added more prosaic items. From the area of the crew's quarters near the stern of the wreck we recovered an assortment of terra-cotta cooking vessels, swords, lead fishing sinkers, a set of bronze balance-scale weights, and even a large plate still heaped with chicken bones. A bronze bucket bearing Arabic script suggested that the ship's crew, like most of her glass cargo, was Islamic.

In the end, however, the ship herself emerged as the greatest prize. In her final plunge she had come to rest at the base of a rocky slope that had tipped her on her port side into a bank of sand. The sand had protected that portion of the hull, including the 30-foot-long keel, from shipworms that otherwise would have made short work of it.

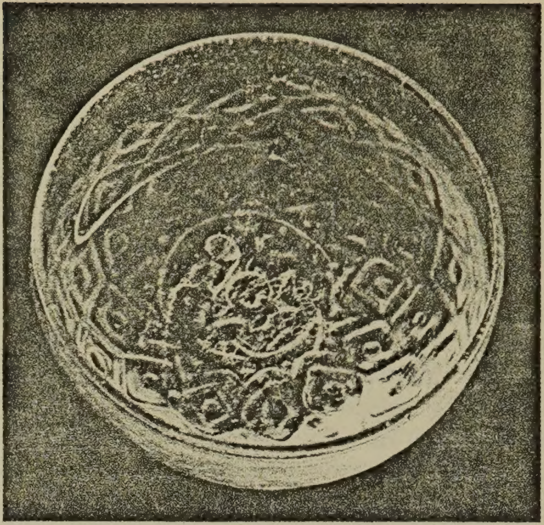
Fred van Doorninck and Don Keith undertook to draft an exact plan of the hull, and as it took shape, we realized it was like no other we had ever seen. Our young Turkish divers were unfamiliar with ancient ship construction, so Fred gave them a short course, using the plan as his textbook.

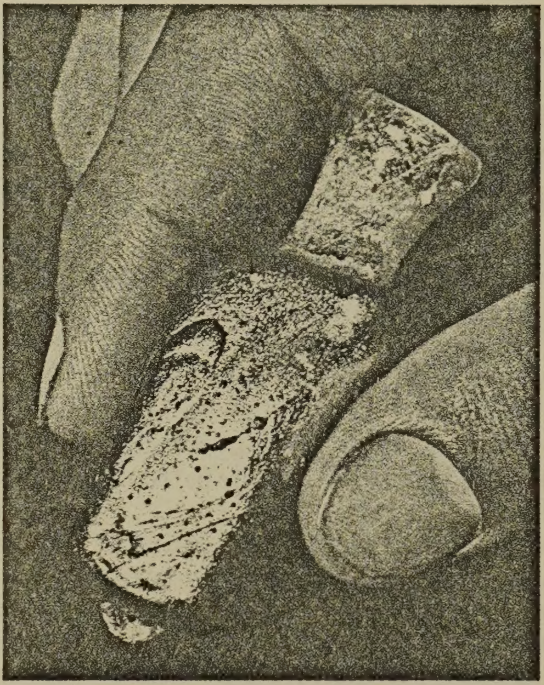
Oldest Ship of Modern Style?

"Early Greek and Roman ships," he began, "were built without an inner framework of ribs. The hull was fashioned from the bottom up a plank at a time, with each plank joined to the one below it by mortise-and-tenon joints. The ribs were inserted *afterward*, then joined to the hull, so the ship had no rigid framework to start with. It was a primitive system and it made for a relatively weak hull, something you'd hardly want in a storm or on a deep-ocean voyage.

"Gradually," Fred continued, "the system changed, as technology advanced and shipbuilders gained experience. Eventually they arrived at the technique still used today, constructing a rigid skeleton of keel and ribs, then adding the planks to it. It was an evolutionary process, and in time made possible the great age of exploration involving voyages far beyond the Mediterranean.

"But when did the change take place? No one is really certain, and of course it didn't happen overnight. At Yassı Ada here in Turkey we excavated a seventh-century wreck that appears to have been a sort of

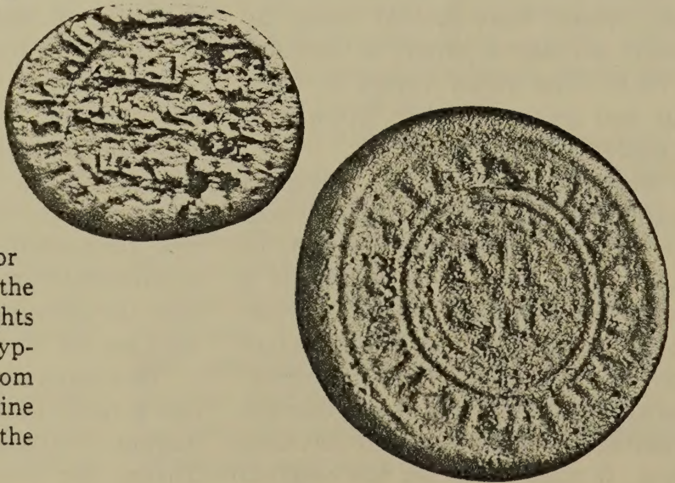


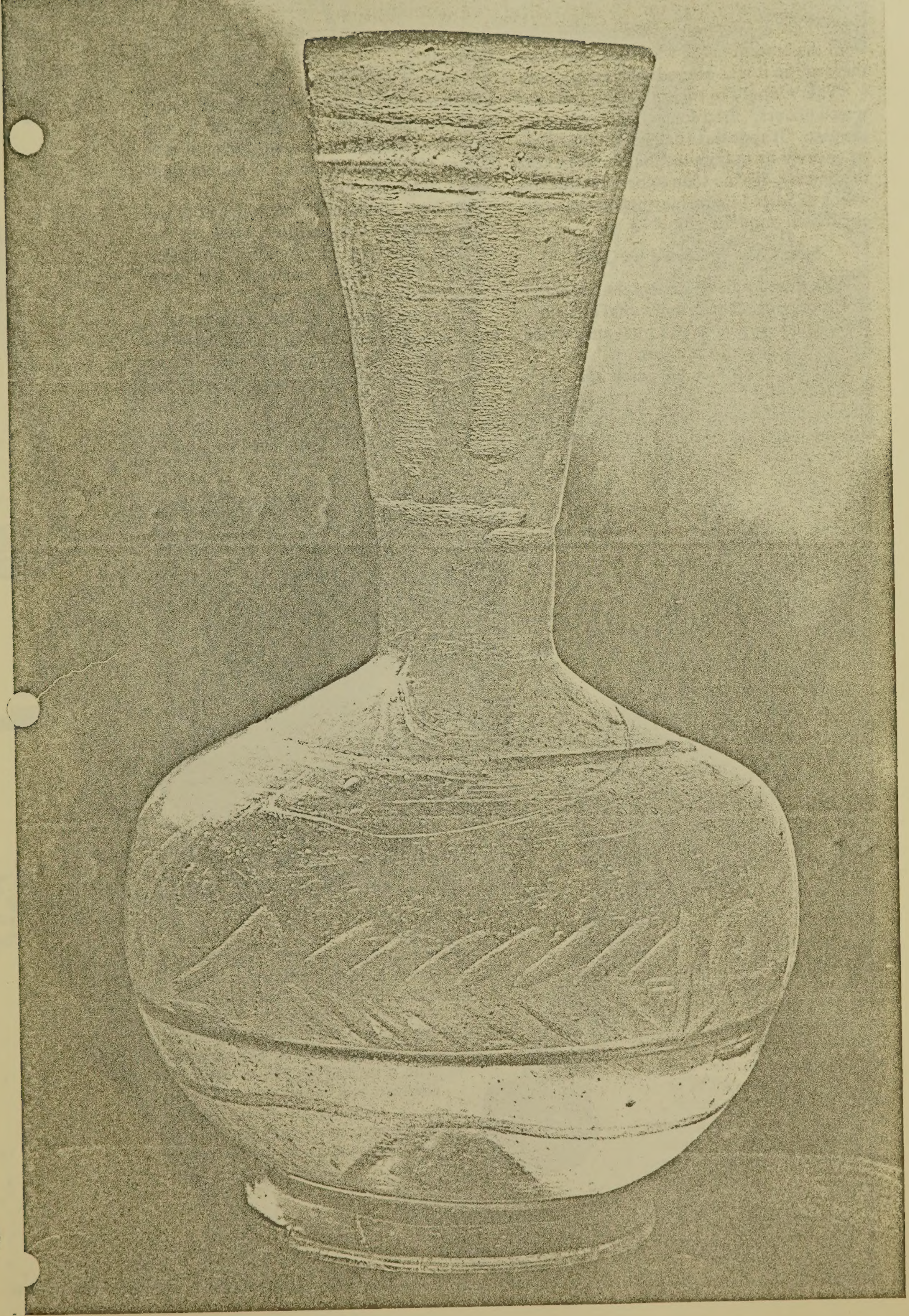


COLORS DANCE in iridescence across a silt-filled bottle found in the stern area of the wreck by Yüksel Eğdemir (**above**), a Turkish official assigned to the expedition. Like an oil slick on water, membrane-thin layers of corrosion caused by chemical breakdown of the glass split light into colors of the spectrum.

Also found in the stern were a delicate mold-blown bowl (**right, top**) and a tiny bottle (**right, middle**) of the kind commonly used for cosmetics and medicines throughout the Islamic world in the 11th century. A bottle with a design engraved by a grinding wheel (**facing page**) represents the finest of the ship's glass, most found near the bow. In a technique still used today, some manganese was added to the molten glass to render it clear as crystal and free of color.

Fortuitous finds that helped the author determine the approximate date of the wreck, these glass balance-scale weights (**right**) were traced to the time of two Egyptian caliphs who reigned successively from 996 to 1035. More than a dozen Byzantine coins found near the keel were dated to the same time.





transition—it was built in the ancient way from the bottom to the waterline, but from there on up it was of modern construction.

"That's what's so exciting about this new wreck of ours," Fred concluded, holding up the plan. "It appears to have been constructed entirely by today's technique, from keel to gunwale. It's too soon to be sure, but the wreck of Serçe Limanı may just be the earliest known 'modern' ship."

Ship's Age Indicated by Coins

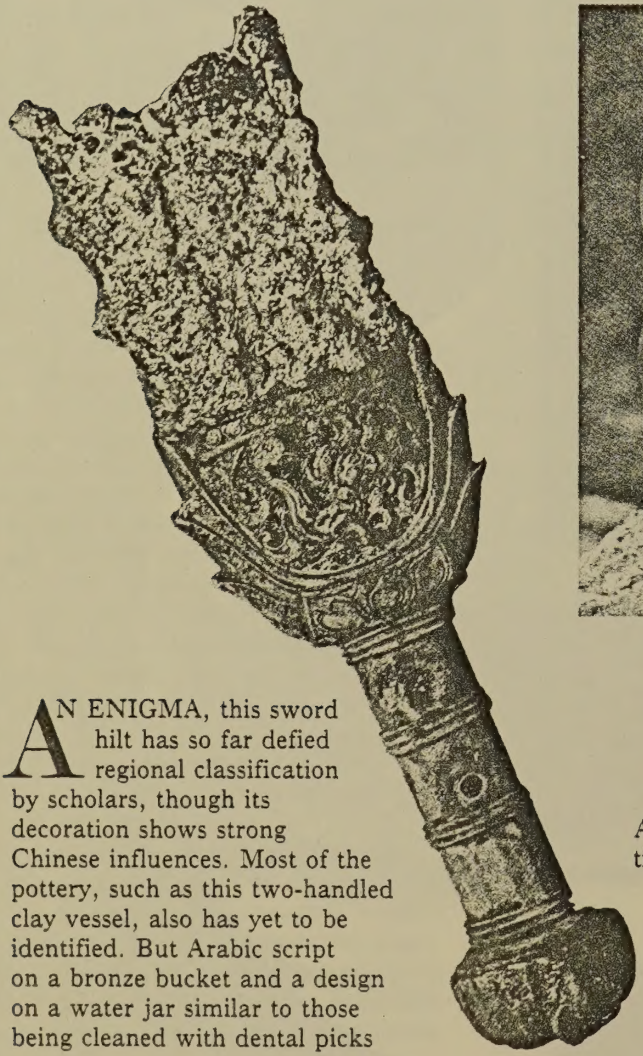
With this new development the age of our wreck became an even more vital question. We seemed very close to a final answer the day we discovered the coins.

They lay in an area alongside the ship's keel, a dozen or more badly corroded copper pieces whose imprint was still recognizable. One side depicted the figure of Christ with a Bible in His hands, and the other bore words in Greek.

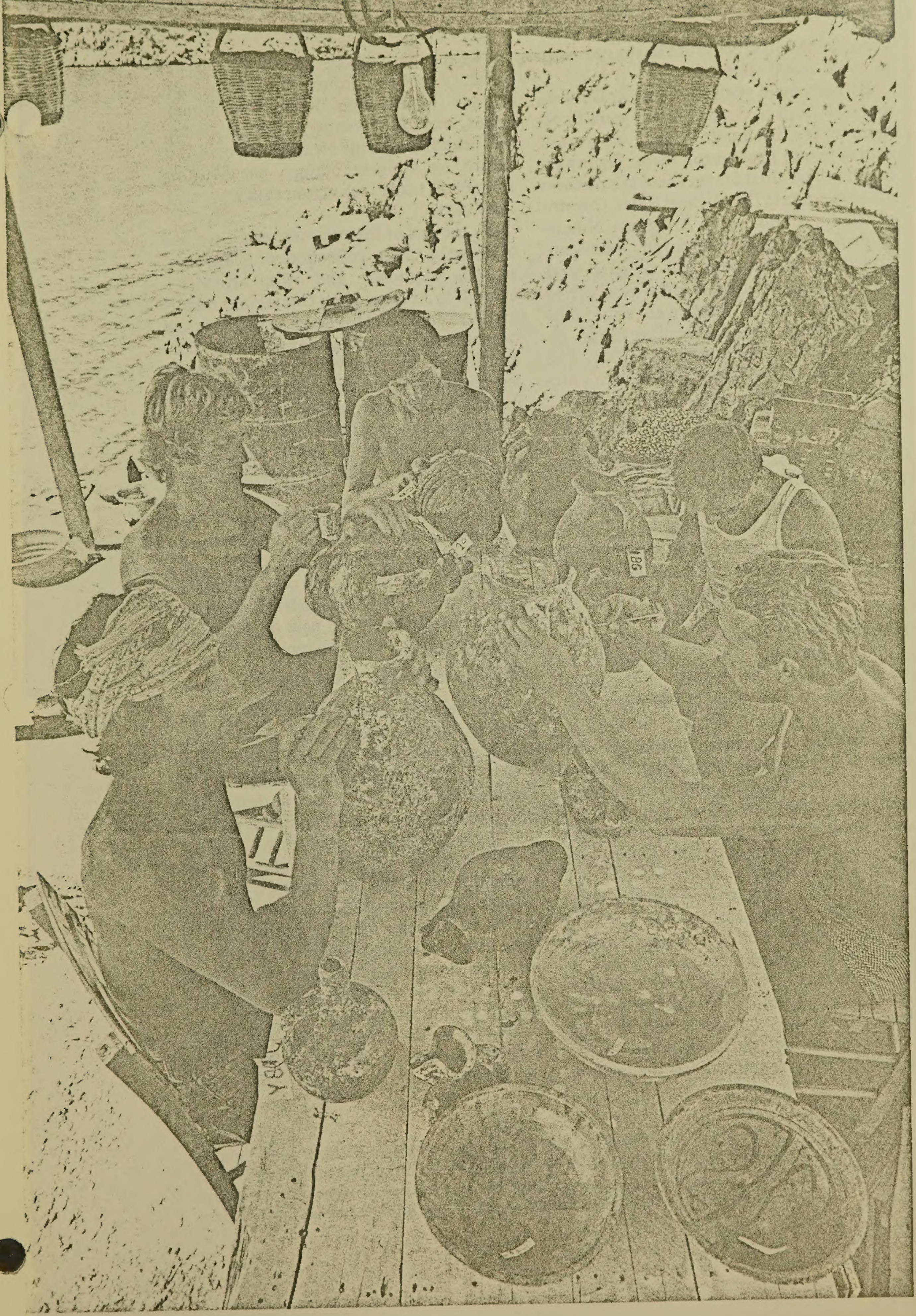
"'Jesus Christ, King of Kings,'" Fred translated. "It's a familiar type of coin, but I can't remember the period when it was minted—somewhere around the tenth century or a little later, I think. If I had the right books, I'd know for sure."

Not long afterward Fred returned to the United States, and within a week we received a cable from him, relayed from Marmaris: "COINS DATE BETWEEN 970 AND 1030, POSSIBLY 989 AND 1020."

At last we had a rough date for our wreck, one that was to be corroborated later by still another find. Among the ship's cargo we recovered four beautiful glass balance-scale weights with Arabic script (page 788). In ancient times such objects were used to weigh coins and precious substances like gold or



AN ENIGMA, this sword hilt has so far defied regional classification by scholars, though its decoration shows strong Chinese influences. Most of the pottery, such as this two-handled clay vessel, also has yet to be identified. But Arabic script on a bronze bucket and a design on a water jar similar to those being cleaned with dental picks (facing page) support the theory that the ship is Islamic. Imitations of Chinese porcelain, like the bowl at left foreground, were popular throughout Islam then. After the summer of 1978, when the ship's timbers are to be carefully raised and treated with preservatives, the adventure of discovery will be replaced by tedious archeological chores. Years of restoration, cataloging, and research may pass before the full history of the ship is revealed.



gems, for the glass could not be shaved down as could metal weights.

By agreement with the Turkish Government all finds at Serçe Limanı were to remain in Turkish hands, though we were of course free to photograph them. On my return to the United States I sent the pictures of the weights to Dr. Michael Bates, Curator of Islamic Coins at the American Numismatic Society in New York. Dr. Bates confirmed my belief that the weights were Egyptian and dated them in the same period as the copper coins. Three were issued during the reign of the Egyptian caliph al-Hakim bi-Amr Allah, A.D. 996-1021. The fourth weight was issued by al-Hakim's successor, between 1021 and 1035.

Next Riddle: Is Ship Greek or Islamic?

While the coins and the glass weights give us a probable date for our wreck, somewhere in the early 11th century, they complicate the question of the ship's origin. The coins are Greek, and therefore obviously Byzantine, but the weights are Islamic. So are the bronze bucket and much of the cooking ware, suggesting an Islamic crew. But then the amphorae bear Greek inscriptions.

Both Greek and Islamic ships plied the waters between the centers of their empires—Alexandria, Egypt, and Constantinople, the heart of Christian Byzantium. Ships of other nations also frequented what today is Turkey's southern coast. On voyages to the western Mediterranean, Islamic ships often preferred to pay tribute to Constantinople for right of passage rather than take the more dangerous route along the North African coast.

In an indirect way our Serçe Limanı wreck even has ties with the Far East. On his visit to the site, Bob Brill, the glass expert from Corning, was accompanied by a specialist in pottery, Professor Frederick Matson of Pennsylvania State University. Examining our pottery bowls and cooking vessels, Professor Matson pointed to the streaks of glaze running down the insides.

"That's an Islamic imitation of T'ang Dynasty pottery from China," he said. "Trade with China dates from Roman times, and ninth-century Chinese pottery has been found in the Near East. Possibly in return for Chinese pottery, the Muslims sometimes traded what your ship was carrying—glass."

By the end of the summer season we had amassed a huge collection of glassware, shards, amphorae, and other artifacts—enough to keep us busy cataloging, restoring, and analyzing for years. Though it had been a season of spectacular finds, the most exciting discoveries will come from libraries, museums, and laboratories, far from our unknown ship's grave beneath the sea.

Loading our treasure aboard the diving barge, we prepared to tow it back to Bodrum, whose excellent museum had agreed to receive it.

We had left one item till the very last—the amphora in which Fred the octopus lived. Reluctantly we coaxed him out and brought the jar to the surface for the possible clues it might later yield. Oğuz reported that Fred had cheerfully taken up new quarters in a sheltered portion of the wreck.

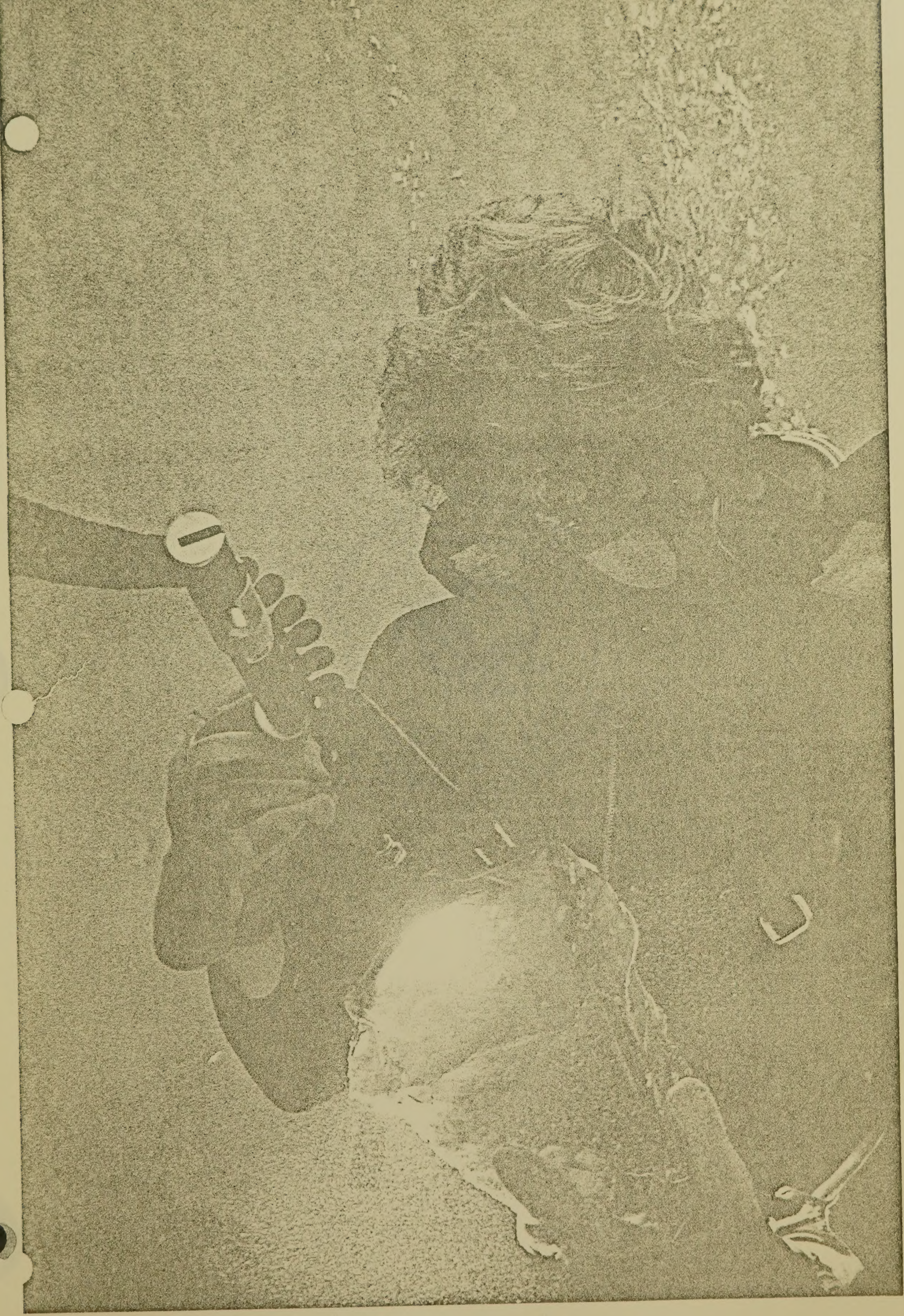
The Mystery—and Challenge—Remains

And there the hulk lies, under a protective blanket of sand, awaiting the day when it, too, is returned to the surface. With the hull carefully preserved and restored, we will learn a great deal more about its design and construction, perhaps filling major gaps in the history of early shipbuilding.

With luck we will learn our ship's port of origin, her probable destination on the final voyage, and even the route she took. The crew's belongings and a reconstruction of their living quarters may give us an insight into who these people were, what life aboard their 11th-century craft was like, and perhaps how that life came to an end.

To me, as an underwater archeologist, such knowledge is even more valuable than the finest glass. □

IGNITED BY A STROBE LIGHT, particles of iron in a chunk of cullet light the deep with a candescent green fire as Robin Piercy brings it to the surface. Nearly half a ton of this raw glass was found in the wreckage. In some unknown glassworks it was destined to be melted down and fashioned into treasures of finished glass.



UNDERWATER SPECIALISTS
"ARCTIC EXPERTS"
"CALGARY, ALTA."
DIVERS AND SALVORS

MARTECH INTERNATIONAL, INC. offers the remote controlled television vehicle TREC for subsea inspection and maintenance services in water depths to 1200 feet and in currents up to 2 knots.

The TREC vehicle is a lightweight, easily maneuvered, subsea vehicle ideally suited for "live boat" type pipeline surveys. It may also be used for bottom surveys and subsea structure inspection and other underwater operations which can be done without the need for manned diving capabilities. Equipped with a low-light-level, high performance television camera with pan and tilt, the TREC vehicle can be used indefinitely, since power for propulsion, control, electrical and video packages — as well as for an optional manipulator arm — is transmitted from the surface to the vehicle through an umbilical cable. Miniaturized electronic components keep the TREC vehicle a compact 45″ × 35″ × 38″ in size, and it weighs only 350 lbs.

The TREC television package provides a viewing range of ±110 degrees pan and ±90 degrees tilt from the vehicle's center line. Additionally, the vehicle can be maneuvered to gain more viewing field. Two 250-W underwater lamps provide illumination. Each of the lamps is adjustable, both in physical vehicle location and in output wattage, to optimize video quality over a wide range of water clarity.

Some of Martech's TREC units are fitted with a three-function manipulator. Work functions of the manipulator include attach, disconnect, grip and cut. Motions include upper arm up and down, forearm in and out, and hand open and shut.

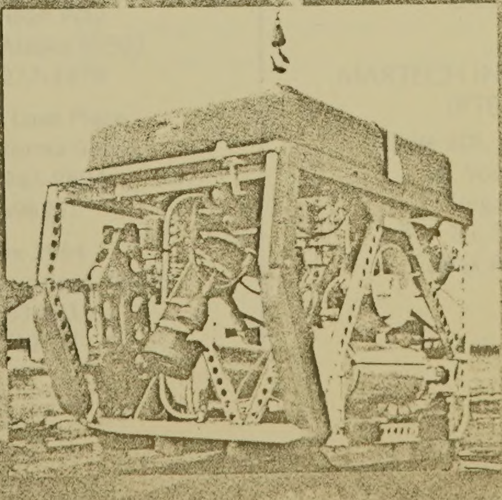
Four 1½ horsepower, 120-volt 60-Hz electric thrusters provide fore and aft, lateral and vertical movement of the vehicle. These motors are very simple, being virtually identical to those used in conventional hand tools. The motors can be quickly removed and replaced, if need be, even at the diving site. The surface control station consists of a control console which incorporates vehicle control and propulsion, light intensity, camera pan/tilt and focus, and manipulator controls. Displays are included for television, vehicle depth and bearing in the control panel.

The TREC is launched with a deck-mounted davit winch assembly. The vehicle's lightweight design, coupled with its all-aluminum open frame structure, supported by a syntactic foam ballast package, make both launch and retrieval relatively simple. Because of the open frame, maintenance can be performed quickly and easily, even at the diving site. Down time is low.

The 1500-ft., 6000-lb. working strength umbilical is tended from the surface.

The small size, the ease of operation and maintenance, and the excellence of its video package make the TREC from Martech International, Inc., an intelligent alternative to the use of expensive manned diving systems for subsea visual survey of pipelines, bottom conditions, and structure inspections. With full monitoring of vehicle functions, the TREC tethered remote vehicle can be operated around the [illegible] the main limiting factor being [illegible] endurance of the individual [illegible]

OBSERVATION—MAINTENANCE MARTECH TREC SYSTEMS



SPECIFICATIONS

VEHICLE

Maximum Operating Depth: 366 meters (1200 feet)
Maximum Operating Current: 2 knots
Viewing Range: 5-7 meters (17-23 feet) Clear water, normal on-board lighting
Speed: Forward — 2.0 knots. Reverse — 1.5 knots. Port/Starboard — 1.5 knots. Up/Down — 1.5 knots.
Working Strength of Umbilical: 6000 lbs.
Location and Recovery Devices: Acoustic beacon, strobe flasher, locator pinger

CONTROL CONSOLE

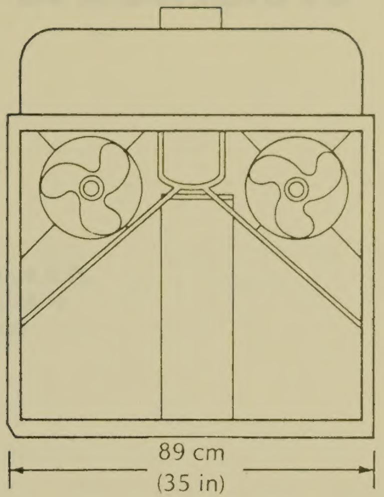
Displays: Video, depth, heading
Vehicle Controls: Thruster propulsion forward/reverse, left/right, heading direction, light intensity, manipulator
Television Controls: Camera focus, camera tilt, TV and video recorder

POWER SUPPLY

Input Power: 120 VAC — single phase 60Hz
Vehicle Power Distribution: 120 VAC, 5 VDC, 8 VDC, 15 VDC

DEPLOYMENT

Umbilical: 1500 feet, manually tended (two 750-feet cables)
Manipulator: Three-function — upper arm up/down, forearm in/out, hand open/shut



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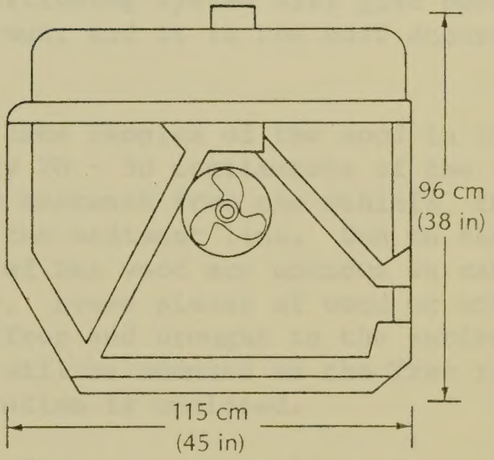

SIDE

MARTECH

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Litho in U.S.A.

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24 Hour Service

TREC SYSTEM

The Trec System is the best and most economical way to approach the Project. The Honeywell RS-7 acoustic positioning system will give positioning well within the proameters set out, and it is the most accurate unit available to date.

A hole saw will be designed to take samples of the wood in the hull. An attempt will be made to jet away 20 - 30 centimeters of the sediment around the vessels by using the backwash from the vehicle, this will allow core samples of the wood below the sediment line. Due to the fact that the sediment and the condition of the wood are unknown we cannot guarantee the results of these procedures. Loose pieces of wood or other articles can easily be picked up by the Trec and brought to the surface. A special Underwater 35MM camera will be mounted on the Trec for this project. A resume of past operation is enclosed.

A complete survey of the decks of the vessels will be done if possible, but, it will be impossible if there is too much rigging in and around the decks.

SUBMARINE (PIONEER)

1 Superintendent
2 Pilots
1 Technician -------------------------------------- $ 3,750.00 per day
Mobilize & de-mobilize about ---------------------- $10,000.00

Although this unit is available we feel it is too large and would stir up the bottom around the wrecks disturbing artifacts . It would also be too large to survey the deck of the vessels because of the rigging. A large crane would be needed to launch the vehicle making the cost prohibitive.

BELL SYSTEM

1 Superintendent
1 Manifold Operator
3 Divers -- $ 4,122.25 per day
Mobilize & de-mobilize ----------------------------- $10,000.00

Depth pay is also charged for each dive. This system would be very expensive and the bottom times would be very limited. Divers alone could not complete the survey.

DIVING TEAM (CANADIAN)

A two man scuba diving team with depth capabilities of 100 feet will be supplied by Underwater Specialists. One diver will double as a Trec assistant and the other will double as a 35MM film developing technician.

SHIP

Johnny D - 100 ft. by 32 ft.
4 point anchor system
Barmax - 32 ft. work boat.
Owned by McKeel Work Boats, Hamilton. They also supplied the boat for the last Trec survey of the vessels.

EVALUATION DEMOSTRATION

It is suggested that an evaluation be run for the committee during a job which is underway, if possible. Otherwise it is suggested that an evaluation be done in the test tank at a Martech location in Houston, Texas, plus observation of video tapes.

To lease a vessel to do an actual evaluation in 300 ft. of water is possible, but, would cost at least $15,000.00. Cost plus 22% basis.

INVOICING PROVISIONS

1. All equipment day rates are stated on the basis of a 24 hour day. Crew members are included in the rate as working 12 hour days.

2. Overtime for crew members beyond 12 hour work day will be charged at $49.00 per hour. Overtime will be worked only in an emergency.

3. RS-7 acoustic position reference and tilt measurement beacons used, have a normal life span of 30 to 120 days between battery re - placements and recharging maintenance.

4. Any special equipment requested by a customer will be charged at cost plus 22%.

5. In the event a Trec vehicle becomes fouled, the cost of retrieval will be billed to the customer.

6. Shut down periods due to remote vehicle malfunction over 12 hours automatically stops RCV rental rate until repaired.

7. All cost of repair or replacement of equipment damaged during or not recovered after an operation, ulees the loss or damage is due to the negligence of the contractor, will be billed to the customer at cost plus 22%.

8. All consumables used on the job will be billed at cost plus 22% - (eg - bulbs - batteries, etc).

9. Equipment shipped from Houston, Texas will not be charged for enroute.
   Personnel will be charged for as soon as the leave Houston.

2.3 RCV OPERATIONS

The Martech remote vehicles are used in the inspection and observation of offshore structures, pipelines and sites. Broad area bottom searches and surveys are conducted in platform construction. These remote vehicles are used to guide placement of structures on the sea floor and to guide wellhead stubs into conductors of structures. Pipelines are inspected in routine surveys and for construction damage. Martech uses precision acoustic tracking and positioning equipment to plot positions of objects and rights of way on the sea floor both in relative and geodetic coordinates. Martech remote vehicle technicians have sidescan and search sonar operating and maintenance experience. Many of the Martech personnel are ex-Navy electronic and electrical technicians. All supervisors have offshore diving or remote vehicle experience prior to assignment at Martech.

Specific remote vehicle operations conducted in the past three years include:

1. Exxon U.S.A. - Hondo Deepwater Platform Installation - Martech, using a RCV-225 remote vehicle, provided bottom surveys, inspection of the at-sea lockup between the two halves of the structure, damage inspection, mud-mat base inspections, skirt pile alignment and placement, pile grouting, conductor installation, and assisted in search and recovery of a dropped hydraulic telemetry module. Almost all observation and inspection

work took place at 600 to 800 feet water depths. On one occasion the RCV-225 was lowered down the inside of a structural leg to observe a problem with a malfunctioning packer. During conductor installation the RCV-225 was used to remove debris from a guide at the 800 foot level. The Hondo job was conducted over a five and one half month period. During grouting operations, the remote vehicle remained in the water for over two weeks at a time. During later operations, the RCV-225 has re-inspected selected areas both inside and outside of the Hondo structure.

Martech Management and supervisors have been part of all phases of the Exxon construction task and job planning. Martech has participated both in the overall planning with suggestions to make in-water tasks more efficient as well as in daily task planning. The Martech video recordings are used in every job planning to facilitate an engineering understanding of operations.

2. Shell Sarawak Pipeline Inspection - Another typical job conducted by Martech remote vehicles consisted of 100 percent inspection of a pipeline in Sarawak Borneo for Shell Oil Company. Twelve miles of pipeline were observed and inspected in thirteen in-water hours. Water depths for this operation ranged from 180 to 200 feet. An acoustic tracking system was used to plot the remote vehicle position during boat movement operations. In this same period,

numerous platforms were inspected to determine whether shut in oil wells were leaking.

3. Total Oil Marine Platform Inspection - A Martech remote vehicle has been used to inspect a large North Sea concrete platform structure for Total Oil Marine. In this job the remote vehicle was used to observe and record bottom scour around the outside of the structure including observing damage of the anti-scour mat. The RCV-225 remote vehicle was flown into the open platform cells to observe the lobed walls for damage. The sea wall (Jarlan) was inspected for wave damage. The water depth for this operation was 400 feet. Riser penetrations through the structure were inspected. A survey was made of debris and the video recording was used to direct diver operations. The broad area video inspection of this large concrete structure formed the primary basis for all subsequent diver repair work.

4. Petrobras Brazil Acoustic Positioning and Remote Vehicle - Martech is currently operating remote vehicles in Brazil for the National Oil Company, Petrobras. Among the jobs being performed are bottom surveys, large structure placement observations, pipeline pull-in observations and inspections and construction surveys of deep water tanker production and loading tower system. The water depths average 400 feet. One large structure which was positioned on the sea floor consisted of a one atmosphere

submarine chamber which weighed in excess of 2000 tons. The remote vehicle was used to monitor the lowering and postioning process. Detailed video observation and recording of the base penetration in the sea floor were made. Observation of release of the lowering harness by remote hydraulic actuators was accomplished to assure no entanglement. Later tasks performed including observation of the manned service capsule mate up and release during pipeline pull-in operations.

On two occasions during pull-in operations,-the remote vehicle was used to clear mud off of the pipeline bundle bull-nose before it could be seated into the manifold center port. On another occasion, the remote vehicle was used to physically clear a fouled service capsule bell down-haul cable from obstructions on the manifold center structure. The remote vehicle was used in recovery operations after a diving bell accident.

5. Well Blowout Observations and Salvage Recovery - Martech remote vehicles have been used during offshore well blowout capping operations. One typical operation was conducted for Conoco Oil Company. The remote vehicle was used to determine subsea wellhead damage and surrounding area problems prior to capping operations. It was then used to guide the blowout preventor onto the wellhead and provide visual assurance of well lockup and closure. Other blowout inspections have consisted of flying into the crater created below the mud line by escaping gas.

Other Martech remote vehicle experience includes observing stabing of platform jacket structures over existing wellhead stubs.

Martech remote vehicles have been used to search for lost tools and for their recovery. Normally a search pattern is flown by the remote vehicle. When the tool is found, a diver is dispatched to recover it. The diver is guided by the remote vehicle to the location. Divers are assisted by the remote vehicle lights. The remote vehicle video observation and inspection tape are sometimes used by engineers to instruct divers prior to working on a project.

6. Conoco Wellhead/Platform Stabover - Martech has conducted several observation surveys whereby its remote vehicles have been used to guide deep water platform structures over existing wellhead stubs. In one case, with Conoco Oil Company, a platform was guided over two existing well stubs in 400 feet of water. The wellhead thirty inch conductor pipes were aligned and guided into the platform conductor bell guides. The two wellheads were drilled and stood on 7 foot centers. The construction engineers used the remote vehicle video to guide the derrick crane in lifting the structure.

Martech has conducted three single stabovers for Exxon, Conoco and Texaco in 1978.

........6/-

7. Amoco Pipeline Inspection - Martech completed 153,540 feet of pipeline inspection offshore Gulf of Mexico in 1978. The as laid inspection of the pipeline was conducted behind a conventional pipelay barge. The video observation and recording was accomplished at pipe touch-down and along the route to determine whether damage had occurred.

8. Michigan Wisconsin Gas Company - Martech is currently conducting a pipeline inspection totalling 145,000 feet in the Gulf of Mexico for Michigan Wisconsin Gas Company. This project is being accomplished similar to the Amoco and other pipeline inspection operations.

9. The total "live boat" remote vehicle pipeline bottom inspection conducted to date by Martech amounts to 650,000 feet of pipeline and sea floor linear coverage.

10. Exxon Oil Company, U.S.A. - Martech provided video observation during platform placement for Exxon Oil Company in 340 feet of water off Louisiana Coast in Mississippi Canyon. RCV was used to inspect bottom before platform was launched. Martech looked for depressions or obstructions that would prevent platform from setting level. Once platform was set, the bottom horizontal was inspected to see if it was level on the sea floor. RCV also was used to do general inspection of platform to see if it was damaged during launch.

..........7/-

11. Transo Platform Stabover - Observed stabover for Transco Oil Company in Verm 310. RCV was used to position the platform over six conductors already on the sea floor. The platform was lifted by the derrick barge and positioned by moving the barge with the anchor winches. This was directed by the barge captain and the RCV pilot. The conductors were stabbed through guides in the center of the platform and were lined up within an inch or two.

12. Exxon Oil Company, U.S.A. - Exxon platform in Mississippi Canyon. Observed skirt piles being driven with new Varco tool. Martech aided Varco in detaching their driving heads from the main skirt piles. Some became stuck and had to be worked loose by watching the RCV monitor. Martech inspected all conductor guides looking for obstructions. Trash could be pushed aside by RCV to clear guides for conductors, saving conductors from possible damage. One conductor was dropped and was relocated. The remote vehicle guided the tool used to recover it. Martech also observed grouting operations, saving time as well as grout. The remote vehicle told exactly when to stop pumping grout. The Martech RCV guided an eight-inch pipe through the skirt pile guides from 0 to 380 feet in order to grout the sleeve, also for Exxon. The original lines had become plugged so this new line had to be positioned between the bell guide and the skirt pipe. The weight of the pipe caused it to hang just outside of the bell guide. The vehicle was able to push on the pipe, which caused the pipe to swing. The moment the pipe was in position over the

bell guide, it was lowered. This saved Exxon from shutting down operations to mobilize a bell diving system.

13. Exxon Oil Company, U.S.A. - Martech remote vehicles observed stabover for Exxon Oil Company. RCV was used to position platform over one conductor on sea floor. A bottom survey around the base of the conductor up to 100 feet out was also conducted.

14. Shell Oil Company - Set a platform for Shell Oil in 425 feet of water in Mississippi Canyon 311. RCV was used to locate level bottom and correct depth of water. The original site was too shallow. The RCV searched for the correct depth as the barge was moved to deeper water using depth pressure readout.

After hurricane in the Gulf of Mexico, this platform sank four feet. Martech was called back to inspect bottom around platform and look for possible damage.

15. Shell Oil Company - Martech remote vehicles inspected six platforms for Shell Oil Company in the Gulf of Mexico. RCV was used to inspect all major members of the platform. The remote vehicle could inspect a eight-leg platform in 150 feet of water in four hours without moving the boat. Shell had expected it to take two or three days per platform and to have to move the boat in order to reach both sides.

The remote vehicle operated in up to ten foot seas.

16 Shell Oil Company - A Martech remote vehicle inspected a platform for Shell that had been hit by a work boat. Martech inspected all major members of the platform locating serious damage to several members. The platform was inspected in 1.5 hours.

17 Conoco Oil Company - Martech provided remote vehicle service to observe stabover for Conoco Oil Company in 225 feet of water. RCV was used to position platform over one conductor on sea floor. Inspected mud-mats of the platform once it was set.

Martech also employs precision acoustic position and tracking systems which provide position information of the remote vehicles with respect to the surface vessel and other subsea objects. These Honeywell RS-7 acoustic positioning systems are used in every bottom "live boat" subsea inspection.

The acoustic positioning system is also used to position and orientate structures on the sea floor. In other operations two objects such as diving bells and remote vehicles are guided to one another for operations involving divers. The acoustic system is able to track up to nine subsea beacons while displaying any two simultaneously.

2.4 Acoustic Positioning and Tracking

Martech presently has four Honeywell RS-7 systems which in addition to being used for tracking and positioning remote tethered vehicles, divers and diving bells for live boating, have been used successfully for the positioning of subsea structures and for the positioning of surface structures over subsea structures with an accuracy of one percent of water depths.

By the end of 1979, Martech will be able to provide an integrated system of topside range - range equipment, RS-7 tracking, RCV-225 video and depth information to be able to give actual geodetic as built measurements on the ocean floor at the sight of the actual structure being observed. By mid 1980, Martech will have a full capability of graphically displaying this information with data storage and data evaluation facilities.

This system will be known as the MARNAV system and will have the additional following capabilities:-

As built Pipeline laying data:-

- Touch down point
- Geodetic Barge Location
- Origin/Destination Relation Ships
- Record for later drawings of project

Blow-out data:-

- Location of Debris

- Location of vehicle
- Record for later drawings

Construction:-

- Graphical representation of physical event
- Rapid placement
- Record for later review

Tracking:-

- Positon/direction of all vehicles
- Umbilical limits
- Geodetic data
- Time sync. with video
- Record for later review of noted data

Control:-

- Ability to control a large number of devices (not limited)

Data:-

- Ability to recover data from a large number of devices

Training:-

Onshore Project simulation

MARTECH REMOTE CONTROLLED SUBSEA MAINTENANCE VEHICLES

MARTECH INTERNATIONAL'S second generation subsea remote controlled vehicle is used for surface directed subsea inspection and maintenance tasks at depths to 6,000' +. The low light level, high performance TV camera provides real time viewing of tasks performed. Miniaturized electronics make this a comparatively compact and maneuverable subsea manipulator vehicle, measuring only 52" × 47" × 43" high.

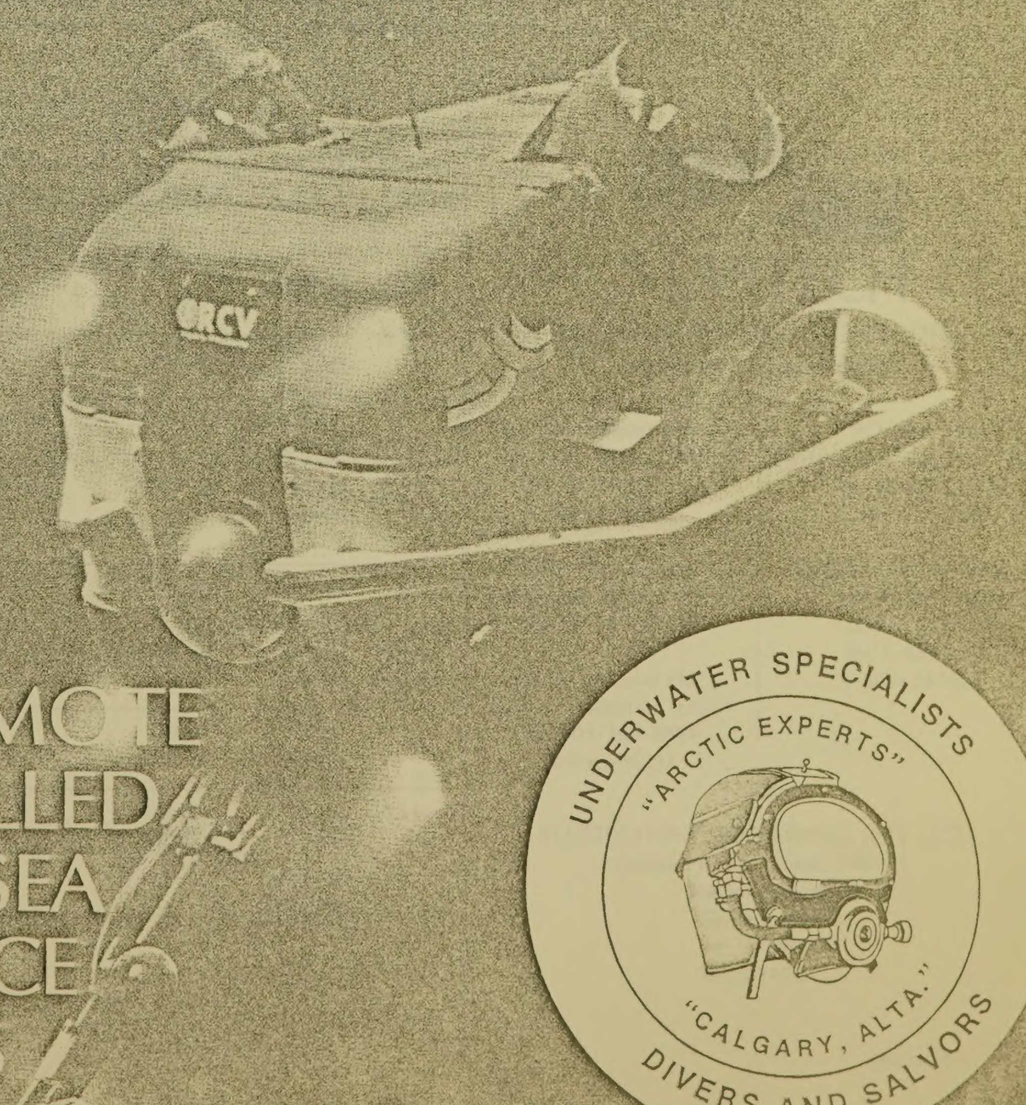
THE VEHICLE EMPLOYS an electro-hydraulic power supply for propulsion and manipulator functions. The manipulator arm reaches forward, above and below the vehicle; and employs interchangable jaws for various projects including object retrieval, control systems operations, and line attachment or cutting. Other vehicle tasks include search, inspection, and debris removal.

DESIGN FEATURES OF THE VEHICLE, essential to successful operations include:

—High performance underwater television with internal pan and tilt to perform detailed visual inspection tasks
—Automatic vehicle depth and heading control to insure vehicle stability
—Fully proportional thruster control for precise maneuvering and station keeping in high currents
—Electro-mechanical buoyant tether cable with submersible winch to minimize cable entanglement hazard
—Compact, highly mobile vehicle for accessibility to confined spaces
—Self contained Deployment Unit for fast, safe, launch and retrieval
—Micro computer control for easy adaptability to tools, sensors, and advanced vehicle control concepts.

THE CONTROL STATION provides for operator orientation with the vehicle by acoustic positioning, search sonar, and vehicle depth display. Features include automatic heading and depth control, fully proportional joystick control of propulsion, and automatic return to center pan control of TV Camera.

REAL TIME PERFORMANCE MONITORING by micro computers keeps operators constantly informed of operational status of all vehicle systems including hydraulic power level, individual thruster power levels, electronic housing temperature, hydraulic oil temperature, telemetry error rate, and water intrusion. All data is displayed on a CRT monitor. Around-the-clock operations of unlimited bottom time are possible.



UNDERWATER SPECIALISTS
"ARCTIC EXPERTS"
"CALGARY, ALTA."
DIVERS AND SALVORS

SPECIFICATIONS

The Remote Controlled Vehicle system is designed to withstand rough handling, high humidity and a wide range of temperature. Minimum size and weight, consistent with easy access to components for maintenance, was a prime design requirement.

Vehicle

The vehicle is a compact, highly maneuverable platform equipped with an advanced television system. Its modular design enables the operator to outfit the basic platform with the sensors and tools needed to perform the job at hand.

The basic vehicle has the following characteristics:

Size: 52" long × 47" wide × 43" high
Weight in Air: 980 lbs.(includes manipulator)
Buoyancy in Water: 15 lbs.
Maximum Operating Depth: 2,000 meters (6,600 feet)
Maximum Operating Current: 3 knots
Viewing Range: 5-10 meters (16-33 feet) clear water, no ambient light
Speed: Forward—3 knots, Reverse—2 knots, Port/Starboard—1.5 knots, Up/Down—1 knot, CW/CCW Rotation—90°/sec.
Pan—90°/sec over 135° arc, Camera Tilt—90°/sec over 180° arc, Camera
Payload: 68 kgs (150 lbs) with all options
Direct Lift Capacity: 45 kgs (100 lbs)
Standard Sensors: High performance television, Vehicle pitch angle, Vehicle roll angle, Vehicle magnetic heading, Vehicle heading rate, Vehicle depth, Camera pan angle, Camera tilt angle, Sea water intrusion, Hydraulic fluid temperature, Electronics temperature
Location/Recovery Devices: Acoustic pinger, Strobe flasher, Tether cable cutter
Manipulator Tools: Manipulator (4 degrees of freedom), Cable cutter, Cleaning brush, Soft line shear, Position retention manipulator.

Sensors

Optional Sensors: Acoustic locator/tracker, Search sonar, Altimeter, Magnetometer Vehicle speed through the water
Vehicle Control: Pitch/Roll—Gravity stabilized, Heading—Automatic control, fully proportional, Depth—Automatic control, fully proportional, Fore & Aft, Left & Right—Fully proportional in direction and speed
Power: Electric/hydraulic, 15 hp
Thrusters, 9" diameter: 2 longitudinal, 2 vertran
Emergency Equipment: Tether Cable Cutter, Battery operated flasher & pinger
Structure: Non-corrosive, non-magnetic, syntactic foam filled glass reinforced plastic (GRP)
Buoyancy: Modular syntactic foam blocks enclosed in GRP fairing
Lights: Four 250-watt Super "Q" lamps
Connectors: Wet mateable
Electronics Housing: Single housing contains all telemetry, sensors, television camera, and micro computer control to eliminate interconnect wiring between housings

Control Station

The displays, controls and telemetry modules are contained in a single ruggedized aluminum container, which is 32" high, 22" wide, and 30" deep. This container can be carried through doors aboard ship by two men. This unit weighs approximately 250 pounds.

Input power 220/415/440 VAC 3φ, 50/60 Hz, L-L/32.62 KVA

Controls and displays are provided as follows:

Television Display: Video annotated with vehicle depth, magnetic heading, camera pan and tilt angles on a CRT monitor
Data Display: Vehicle depth, magnetic heading, camera pan and tilt angles, Vehicle pitch or roll angles, data error rate, time of day, number and direction of tether cable twists, tether footage counter, on a CRT monitor
Bar Graph Displays: Hydraulic power level, thruster power levels, electronics housing temperature, hydraulic oil temperature
Illuminated Switch Bank: Servo mode selectors, accessory controls, data record, camera focus, light controls, tether winch in/out, vehicle release
Alphanumeric Keyboard: Tether cable cutter command key, time of day input, alphanumeric operator input
Vehicle Propulsion Joystick: Proportional translation forward/reverse, left/right, up/down, and heading rotation CW/CCW; automatic depth and heading controls with manual backup; trigger to actuate manipulator jaws, pinger dropper, or film camera as desired
Camera Joystick: Proportional servo control of pan and tilt angles, automatic pan return
Tool and Sensor Display/Control: Manipulator joystick, Strip chart recorder, Sonar display, Vehicle position display, Cut off saw/wire brush control

Deployment Unit

Winch/Skid/A-Frame
Armored cable capacity: 2,500 feet (higher capacity winches available for greater depths)
Armored cable winch rate: Variable from 0 to 100 feet per minute
Armored cable winch maximum pull: 10,000 pounds
Hydraulic power supply
Input power 220 VAC—3φ—50 to 60 Hz or 440 VAC—3φ—50 to 60 Hz (21 kw Maximum)
Launcher
Tether cable capacity: 600 feet
Tether cable winch rate: 50 feet per minute
Tether cable winch maximum pull: 200 pounds

RCV-150 SYSTEM SIZE AND WEIGHT

		SIZE			WEIGHT	
Component	Location	Height	Width	Depth/Length	Air	Water
Vehicle with Manipulator, Cable Cutter, etc.	U/W	109cm 43"	119cm 47"	132cm 52"	444 kgs 980 lbs	− 7 kgs −15 lbs
Control Station	Control Room	81cm 32"	56cm 22"	78cm 30"	112 kgs 250 lbs	
Power Unit	Deck	114cm 45"	122cm 48"	102cm 40"	816 kgs 1800 lbs	
Winch: Without Armored Cable	Deck	147cm 58"	152cm 60"	152cm 60"	1587 kgs 3500 lbs	
Skid/A-Frame	Deck	305cm 120"	183cm 72"	213cm 84"	1587 kgs 3500 lbs	
Launcher with 600' tether cable	U/W	183cm 72"	168cm 66"	168cm 66"	907 kgs 2000 lbs	705 kgs 1550 lbs
Armored Interface Cable		2.92cm 1.15" dia.		758 m 2500 ft	1134 kgs 2500 lbs	
Tether Cable		1.52cm 0.60" dia.		182 m 600 ft	34 kgs 75 lbs	−0.5 kgs − 1 lb
TOTAL SYSTEM					6621 kgs 14605 lbs	

Total system power requirements—440 VAC, 3φ, 60 Hz, 75 kw

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Marine technology in depth.

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PROBLEM PIPELINE IN COOK INLET SUCCESSFULLY REBURIED

By Ben C. Tisdale
General Manager
U.S. West Coast Division,
Martech International, Inc.

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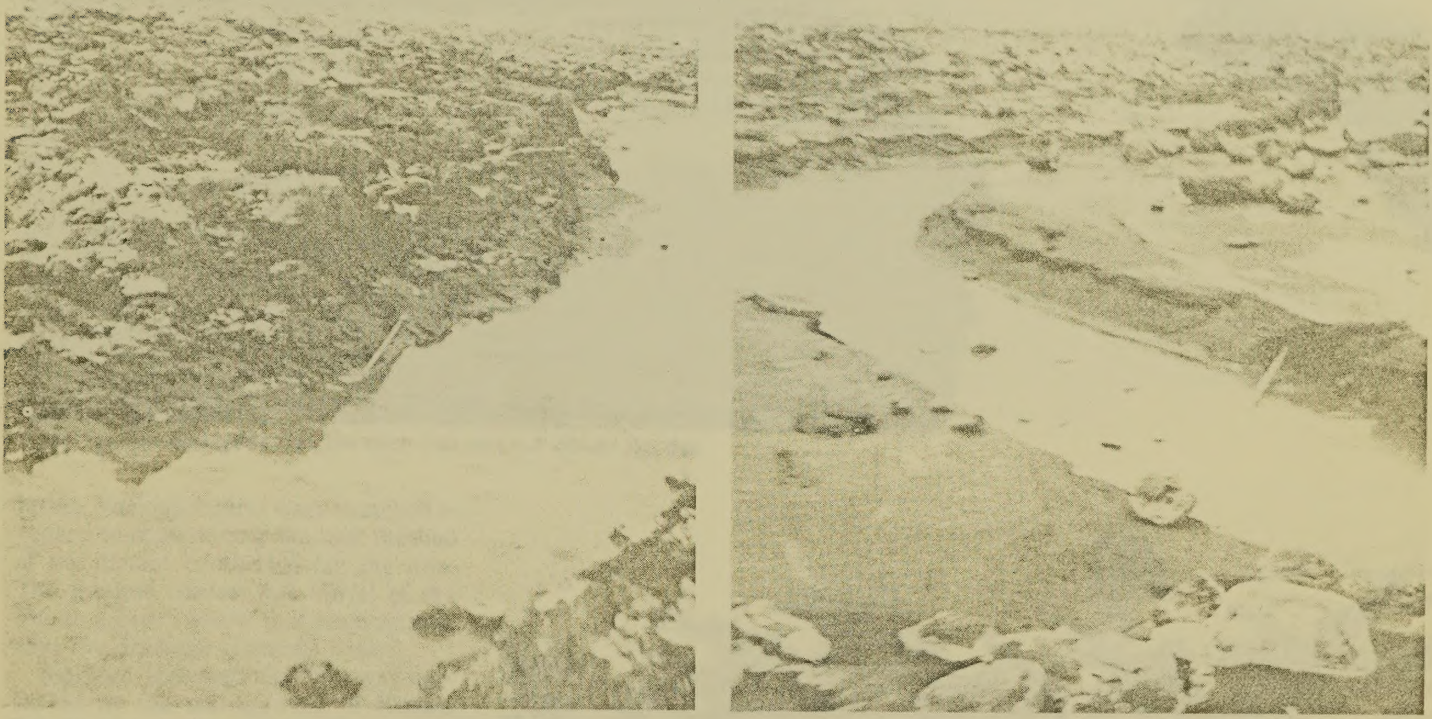
Problem Pipeline In Cook Inlet Successfully Reburied

by Ben C. Tisdale, *General Manager, U.S. West Coast Division, Martech International, Inc., Houston, Texas*



Condition of pipeline just two years after originally buried in the tidal mud flats of Turnagain Arm near Anchorage is shown in these two photos. *In left photo,* line is seen in center of picture alongside channel through the craggy mud floor. *At right,* line almost bridges another channel. Tides in this area vary up to 38 ft.

The Nikiski products pipeline extends approximately 70 miles from Alaska's Kenai Peninsula, across the Turnagain Arm of the Cook Inlet, to terminals at the Port of Anchorage, Alaska. It is a major products line from the Tesoro refinery, transporting gasoline for several oil companies to Anchorage.

The pipeline is constructed of 10¾-in. O.D., API 5L Grade B seamless steel line pipe with a wall thickness of 0.625-in. and a weight of 67.6 lb/ft. The pipe is coated with elastomer and polyethylene X-Tru coat.

During laying of the pipeline in 1976, one of the major obstacles encountered was the 15-mile water crossing of the Turnagain Arm. This area is subject to severe weather conditions and extreme tidal action. Wind blowing off the glaciers is continuous with velocities often reaching 50 to 60 knots. Four tides a day, varying up to a 38-ft range generate currents of over seven knots. Heavy, wind-driven seas often pose additional problems to operations. The deep-water portion of the crossing is in water depths averaging 120 ft, but the final five and one-half miles of the route nearest Anchorage traverses tidal mud flats that are exposed during low tide.

The combination of tide and weather forces acting upon the lay barge resulted in the as-built pipeline having a considerable number of deviations from the originally proposed right-of-way, some of which wander as much as 400 ft off the designated centerline.

The pipeline was originally buried using a five-foot plow attached to a 130-ft stinger and equipped with air and water jets. Unfortunately, due to the slow rate of lay inherent in the stovepipe method of pipeline fabrication, the plowed trench tended to refill before the pipe reached full trenched depth. The result was insufficient depth of burial, complicated by the tendency of the plow to lift when pulled by the barge.

Shortly after completion of the line, the Turnagain Arm started its annual freeze, and in late January 1977, during low tide periods, it was observed that rivulets had eroded the fine-grained silty soil from beneath the pipeline in several locations. Because of these channel migrations, a pipeline with several feet of cover can become exposed suddenly. During the winter of 1977-78, ice and current erosion continued to expose even greater portions of the highly visible, yellow-coated line, attracting the attention of government officials.

At some points, up to 300 ft of line were suspended between drainage channel banks, causing concern that ice pans or ice blocks could induce bending stresses that might lead to failure of the pipe, with attendant environmental pol-

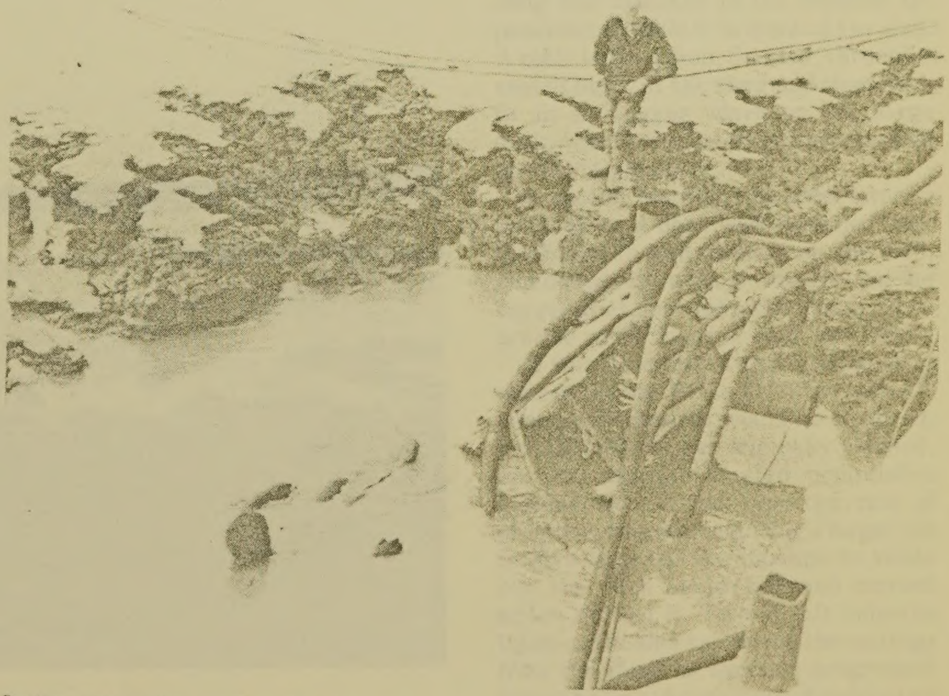
After the tide had gone out, the ditch that was cut looked like this.

lution. Various studies were launched in regard to determining the best method of permanent protection for the line. The method chosen was burial of the line to a depth below that maximum to that the drainage channels occur.

Martech International Inc. was contacted by the management of Nikiski Pipeline to conduct research and investigations of feasibility concerning reburial by hydraulic jet trenching. Martech's Anchorage office determined that the desired results could be obtained using its patented jet sled system and a contract was then entered into during the first week of June 1978.

Prior to beginning reburial of the line, a complete electronic survey was undertaken to establish the actual position of the pipeline in both horizontal and vertical planes as it was known that considerable deviation from the planned right-of-way existed.

This was a necessary step in this situation because, due to the wide tidal range, the barge would be aground during the low tide, occurring every four to six hours. If the barge had been permitted to settle on the pipe, there was a risk of damage to the line, especially since the line was to remain in operation during reburial. The depth of cover over the line was also physically probed and was found to vary from the pipe being exposed (above the surface) to as much as 11 ft deep. These tests illuminated the fact that, in addition to the horizontal deviations from the planned right-of-way, "wiggles" in a vertical plane were also present.

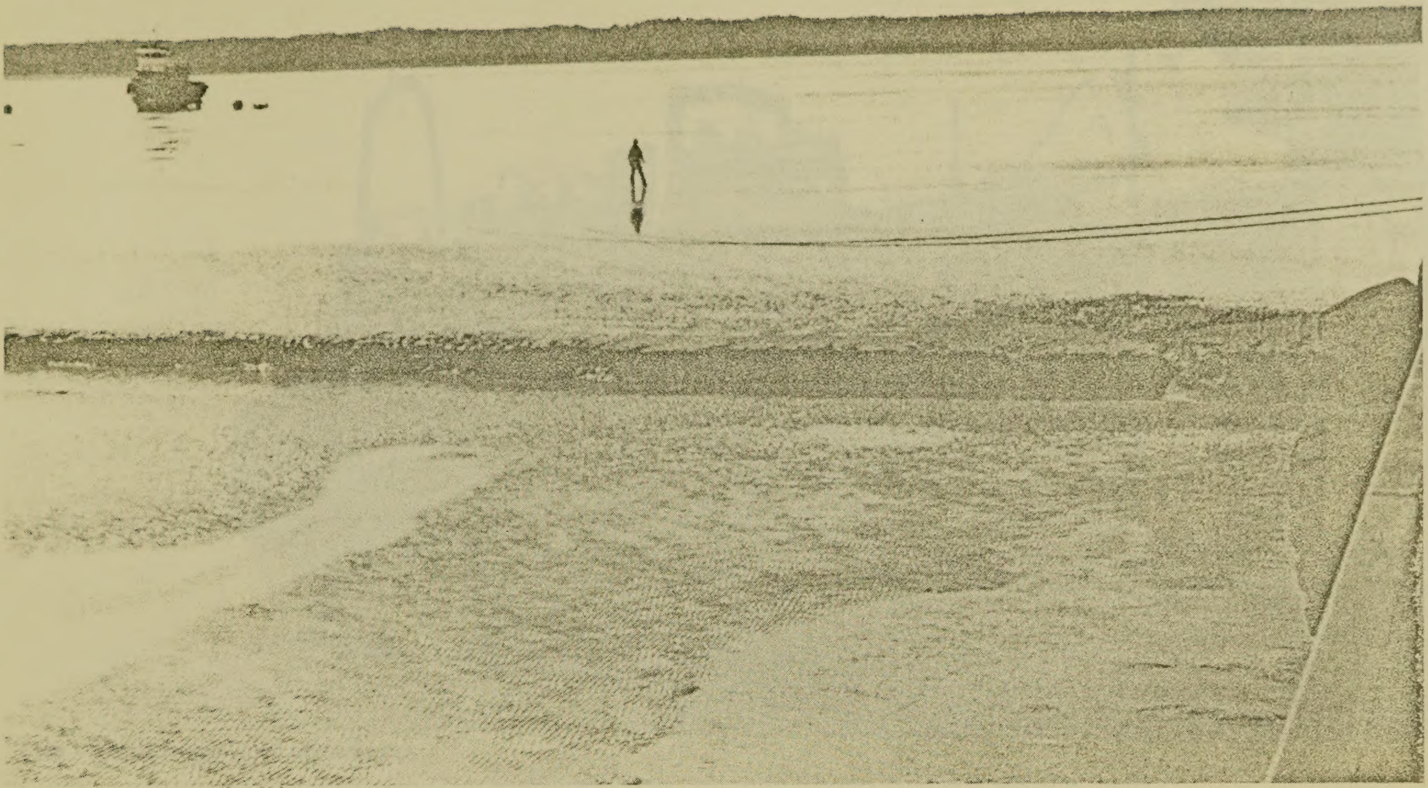


Setting the jetting sled on the pipe.

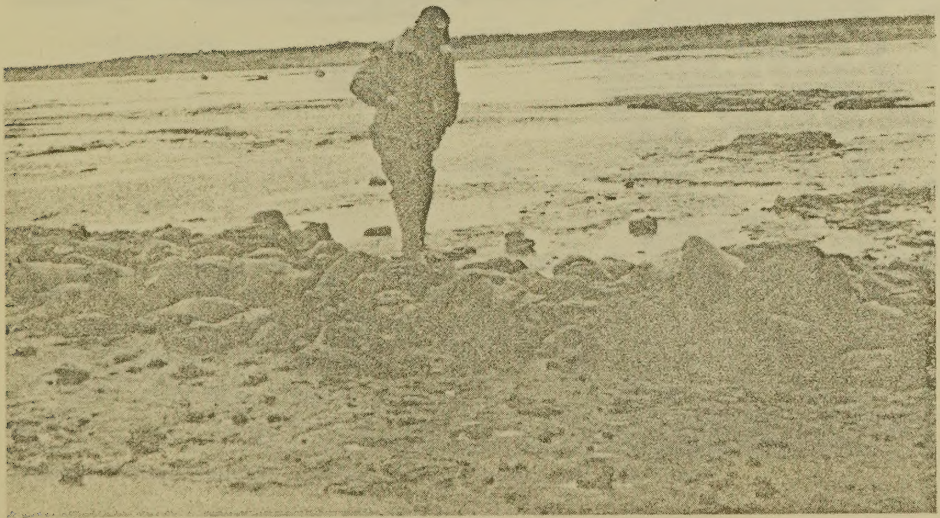
Using the results of this survey, the barge was able to follow the line, never getting closer than 6 ft to or farther than 10 ft from the pipe during the reburial operation across the 28,000 linear ft of mud flat.

Martech's jetting sled is normally self-propelled, employing differential pressure between the cutting jets and the propulsion jets. This provides the advantage of never having to locate the barge directly above the pipeline, as would be required if a traditional towed sled method were used.

When the project was begun, how-



Crewman walks pipeline route across mud flats during low tide. Both barge (foreground) and tug (background) were aground every four to six hours.



Sand bags were placed on pipeline.

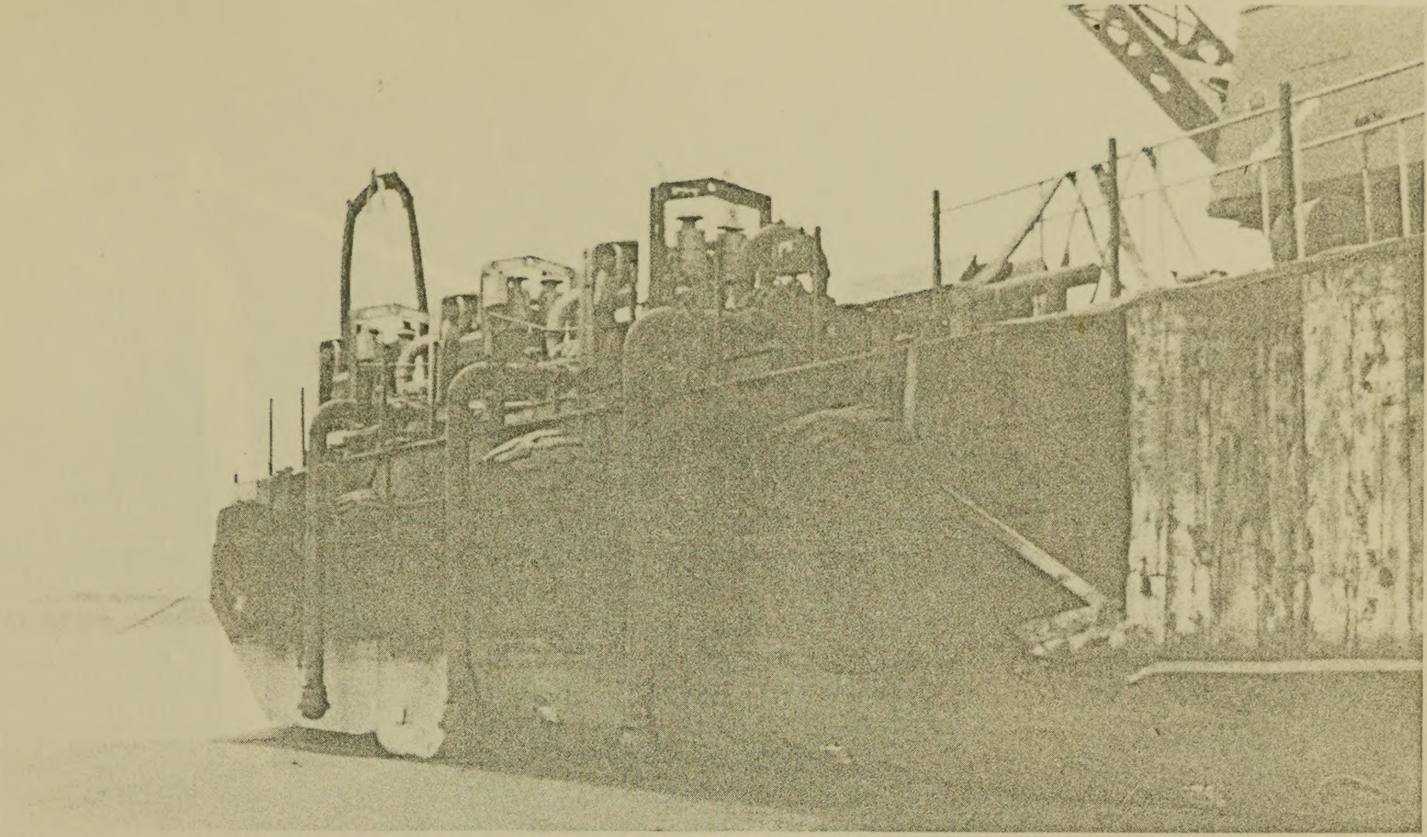
ever, it was soon apparent that the sled's buoyancy tanks (required to keep its in-water weight light enough for self-propulsion without imparting tractive forces to the pipe) posed a drag problem in the transverse currents. The considerable "sail area" of the tanks tended to lay the sled over when operating in these strong currents instead of maintaining the vertical orientation necessary. As a result, a method of pulling the sled along the pipe without positioning the barge over the pipe had to be developed. Although complicating the job, this allowed all available hydraulic (water) pressure to be utilized for cutting the trench and removing the soil from the ditch.

A system was devised whereby a sling was attached to the pipeline approximately 1000 ft in front of the sled. A cable leading from the sled, through a snatch block at the sling and then back to an air tugger winch on the barge deck, was thus used to pull the jet sled down the pipeline.

A second method was used later in the project. A boom was extended from the barge to pull directly on the sled, eliminating the periodic resetting of the tugger lines, but this method was not as precise when winds or seas were high.

It was determined that a ditch 30 ft wide at the top, 9½ to 10 ft deep, and 6 ft wide at the bottom would be required. A smaller ditch was originally planned, but the change in sled propulsion method slowed the expected rate of progress, thereby requiring a larger cut to give time for the pipeline to settle into the ditch before tide and current action refilled it. Two air-lift inductor tubes on the sled vacuumed the cuttings from the ditch as the sled progressed down the line. An average of eight cu yd of soil had to be removed from the trench for each linear foot of pipe traversed.

The soil in this area is tightly consolidated sand, very fine grained and erodible. This silty material was hard on the surface, but once penetrated it became very quick and flowed easily. A stratum of dense hard-pan underlaid the fine sandy soil in many places, varying in



Side view of barge when tide was out.

Pipeline, before reburial, was found below mud line with little cover.

depth from 18-in. to 6 ft, and in thickness from 8 to 14-in. The pipeline seemed to have settled to the hard-pan depth in most cases. Below this stratum the soil was the same consistency as that overlaying.

The pipe trench stayed open for three to four tide cycles, during which it progressively filled in with a slurry of sand, mud, and water. Re-silting of the ditch was expected to be a major problem but proved not to be.

Barge handling and positioning was a matter of constant concern during the operation. Currents were unpredictable in velocity and more importantly, in direction, but could always be counted upon to increase during tidal movements. Combine these everchanging forces with the horizontal deviations in the pipeline route and the critical element, that of keeping the barge away from the pipe, becomes quite a problem.

In addition to the difficulties in maintaining barge-to-pipeline horizontal position, vertical bends in the pipeline required continual raising and lowering of the jetting sled to accommodate differing thicknesses of overburden and maintain desired cutting depth.

Despite the difficulties in this project, the 28,000 linear feet of tidal zone trenching was accomplished at an average rate of progress of 150 ft per hr. The Nikiski products pipeline has now been effectively "planted" and for the most of the route, the cover is so thick that the pipeline cannot be found with a metal detector. In some areas, depth of cover is over 14 ft.

About the Author

Ben C. Tisdale *has a background of over 22 years in the offshore petroleum industry, having worked his way up through various positions from roughneck to vice president of a major offshore construction company, then serving in the capacity of president in his own pipeline contracting and consulting company before joining Martech. He also has many inventions and innovations in marine construction, production, and pipeline methods and equipment to his credit. As general manager, U.S. West Coast and Alaska Division, Tisdale is responsible for administration and management of Martech's western U.S. operations.*

OBSERVATION— MAINTENANCE MARTECH TREC SYSTEMS

MARTECH INTERNATIONAL, INC., offers the remote controlled television vehicle ("TREC") for subsea inspection and maintenance service in water depths to 1200 feet and in currents up to 2 knots.

The TREC vehicle is a lightweight, easily maneuvered subsea vehicle ideally suited for "live boat" type pipeline surveys. It may also be used for bottom surveys and subsea structure inspection and other underwater operations which can be done without the need for manned diving capabilities. Equipped with a low-light-level, high performance television camera with pan and tilt, the TREC vehicle can be used indefinitely, since power for propulsion, control, electrical and video packages — as well as for an optional manipulator arm — is transmitted from the surface to the vehicle through an umbilical cable. Miniaturized electronic components keep the TREC vehicle a compact 45" × 35" × 38" in size, and it weighs only 350 lbs.

The TREC television package provides a viewing range of ±110 degrees pan and ±90 degrees tilt from the vehicle's center line. Additionally, the vehicle can be maneuvered to gain more viewing field. Two 250-W underwater lamps provide illumination. Each of the lamps is adjustable, both in physical vehicle location and in output wattage, to optimize video quality over a wide range of water clarity.

Some of Martech's TREC units are fitted with a three function manipulator. Work functions of the manipulator include attach, disconnect, grip and cut. Motions include upper arm up and down, forearm in and out, and hand open and shut.

Four 1/4 horsepower, 120-volt, 60-Hz electric thrusters provide fore and aft, lateral and vertical movement of the vehicle. These motors are very simple, being virtually identical to those used in conventional hand tools. The motors can be quickly removed and replaced, if need be, even at the diving site. The surface control station consists of a control console which incorporates vehicle control and propulsion, light intensity, camera pan/tilt and focus, and manipulator controls. Displays are included for television, vehicle depth and bearing in the control panel.

The TREC is launched with a deck-mounted davit winch assembly. The vehicle's lightweight design, coupled with its all-aluminum open frame structure, supported by a syntactic foam ballast package, make both launch and retrieval relatively simple. Because of the open frame, maintenance can be performed quickly and easily, even at the diving site. Down time is low.

The 1500-ft, 6000-lb working strength umbilical is tended from the surface.

The small size, the ease of operation and maintenance and the excellent quality video package make the TREC from Martech International, Inc. an intelligent alternative to the use of expensive manned diving systems for subsea visual survey of pipelines, bottom conditions and structure inspections. With full monitoring of vehicle functions, the TREC tethered remote vehicle can be operated around the clock, the main limiting factor being the endurance of the individual

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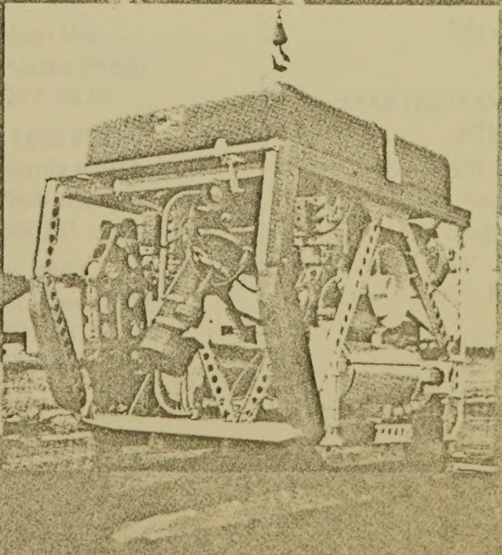


SPECIFICATIONS

VEHICLE

Maximum Operating Depth: 366 meters (1200 feet)

Maximum Operating Current: 2 knots

Viewing Range: 5-7 meters (17-23 feet) Clear water, normal on-board lighting

Speed: Forward — 2.0 knots. Reverse — 1.5 knots. Port/Starboard — 1.5 knots. Up/Down — 1.5 knots.

Working Strength of Umbilical: 6000 lbs.

Location and Recovery Devices: Acoustic beacon, strobe flasher, locator pinger

CONTROL CONSOLE

Displays: Video, depth, heading

Vehicle Controls: Thruster propulsion forward/reverse, left/right, heading direction, light intensity, manipulator

Television Controls: Camera focus, camera tilt, TV and video recorder

POWER SUPPLY

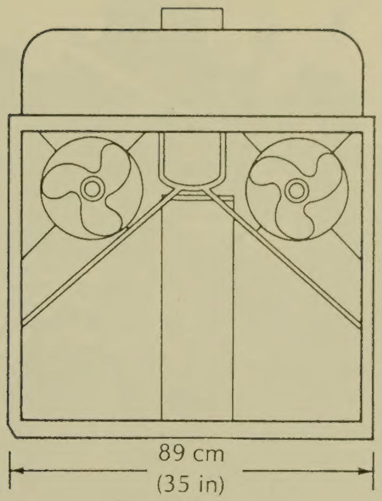
Input Power: 120 VAC — single phase 60Hz

Vehicle Power Distribution: 120 VAC, 5 VDC, 8 VDC, 15 VDC

DEPLOYMENT

Umbilical: 1500 feet, manually tended (two 750-feet cables)

Manipulator: Three-function — upper arm up/down, forearm in/out, hand open/shut



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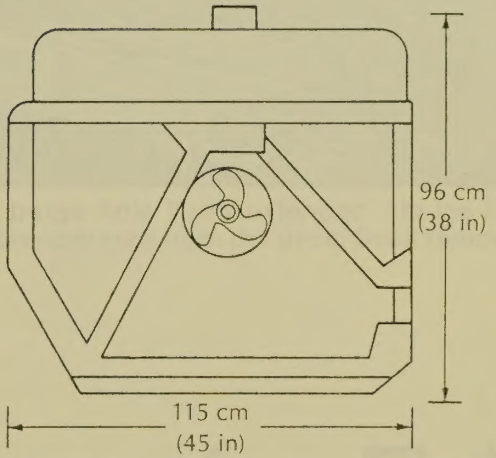

SIDE

MARTECH

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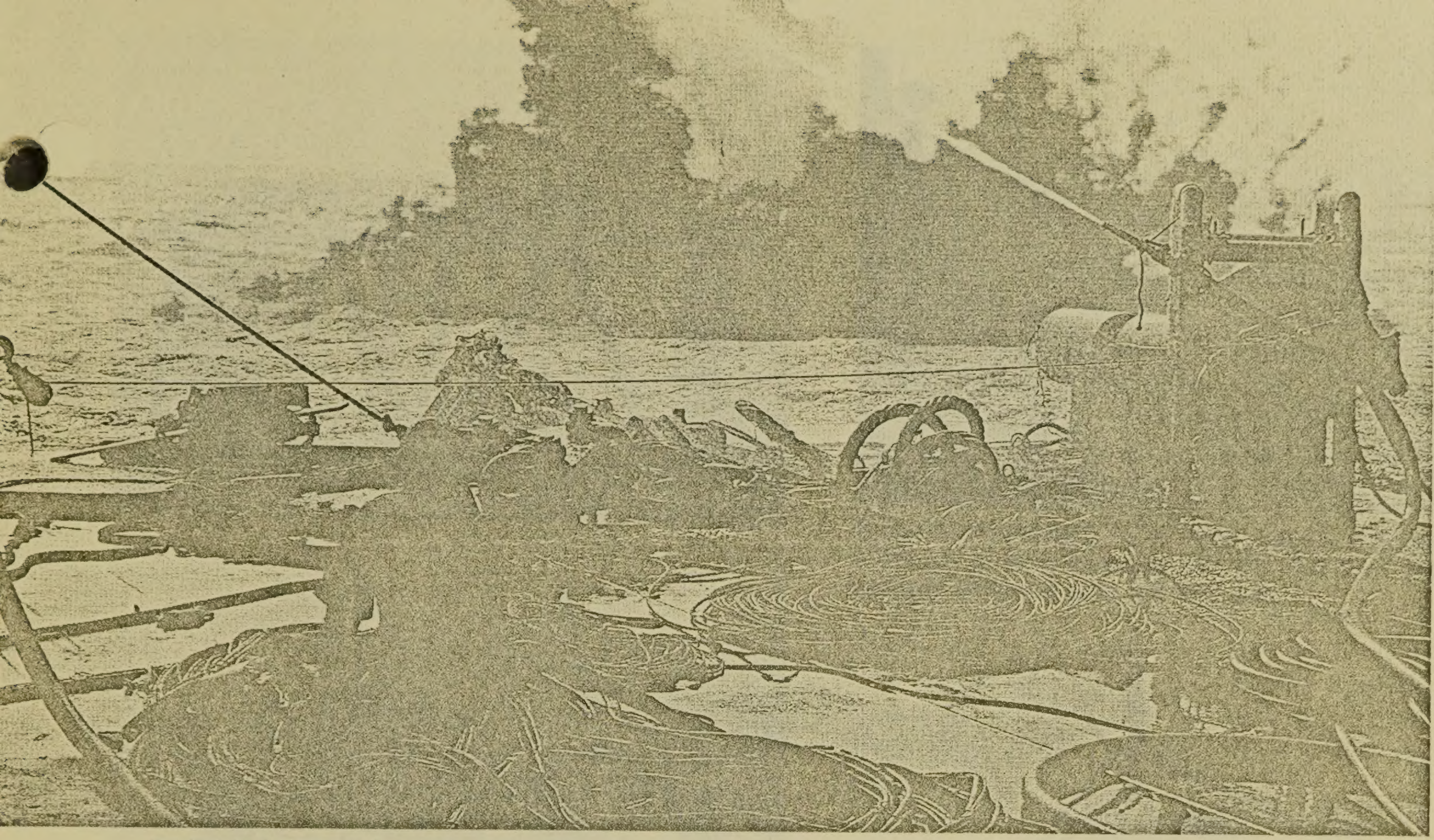


BARGE EXTENDS INTO FLAMES. One corner of the barge *Able Turtle* extended into the flames of the blowout while divers and an unmanned submersible operated from the deck. Deck temperatures on that corner were around 145°F.

Offshore Mexico

International Companies Fight 30,000-bopd Blowout

Control efforts have been unsuccessful on the Ixtoc 1, but containment of the spilled oil is hampered by strong surface currents. Damage to the ecology is minimal.

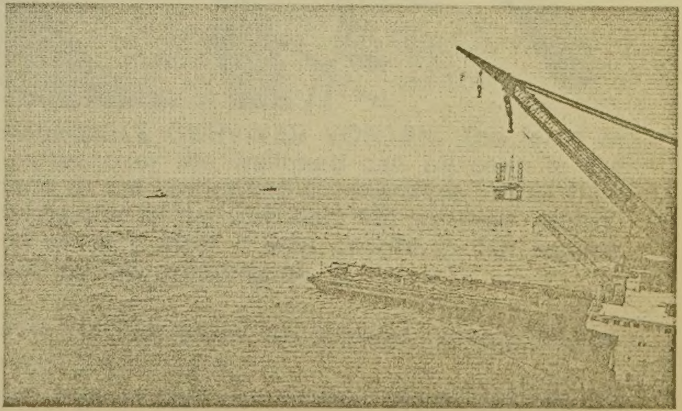
Scott L. Weeden, Associate Editor

Roaring flames on the surface of the Gulf of Mexico mark the location of the Ixtoc 1 well, which blew out on June 3. A fleet of ships surrounds the flames and the spilled oil while a jack-up drilling rig drills a relief well.

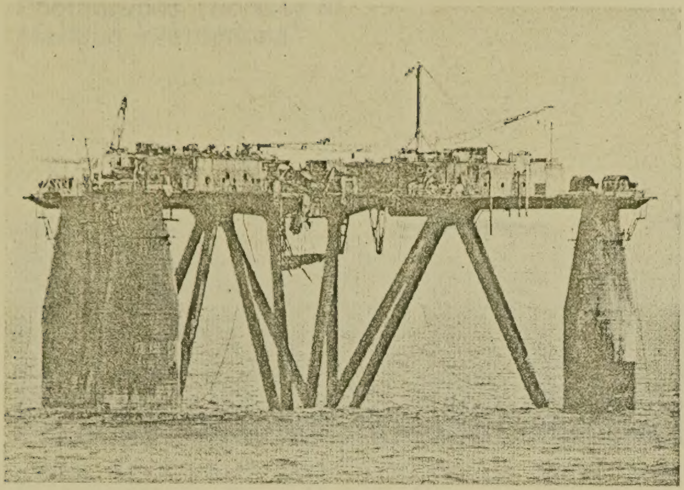
Efforts to control the well have been unsuccessful so far. However, adverse effects have been contained to an almost unprecedented degree by Pemex and its subcontractors.

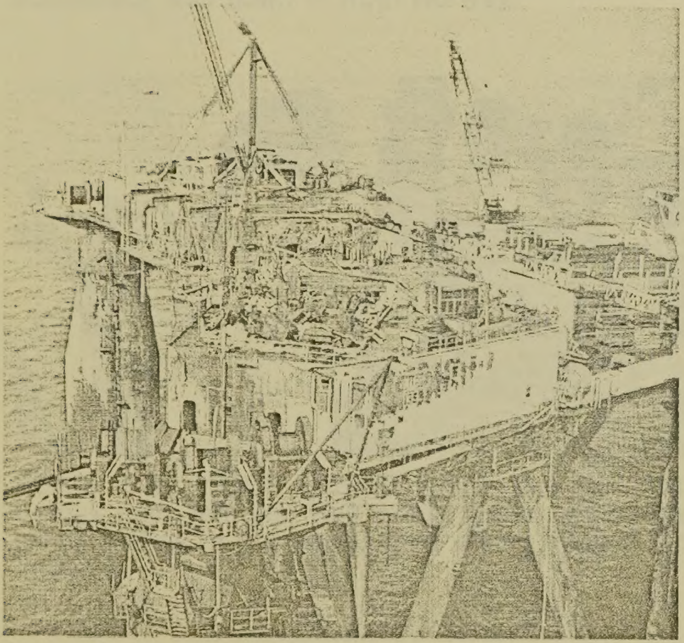
The control effort marks the first time a manned submersible has been used in fighting a blowout and possibly the first usage of an unmanned submersible in surveying the wellhead.

The blowout. The semi-submersible *Sedco 135*, under contract to Perforaciones Marinas del Golfo S.A. for



RELIEF WELL. The jack-up rig *Azteca*, background, is drilling the relief well about 2,600 ft from the wellsite.





FIRE DAMAGE. The extent of the damage to the semi-submersible *Sedco 135* was extensive. All 63 crewmen escaped safely. The rig began operations in 1965.

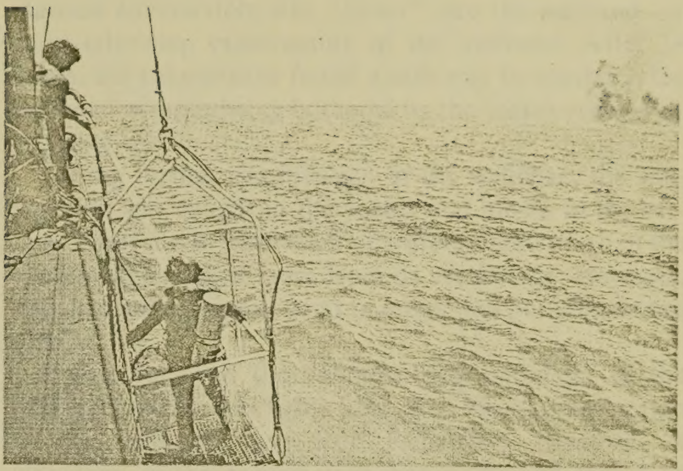
Pemex, was drilling the Ixtoc 1 in 164 ft of water in the Bay of Campeche. The rig had drilled the well to 11,683 ft and was tripping out of the hole when the fire started.

Gas from the hole ignited when it reached hot pump motors on the rig, according to Pemex. All 63 crewmen escaped safely. Luckily, the crew had run through an abandon ship exercise two days before and all safety equipment was in top operating condition.

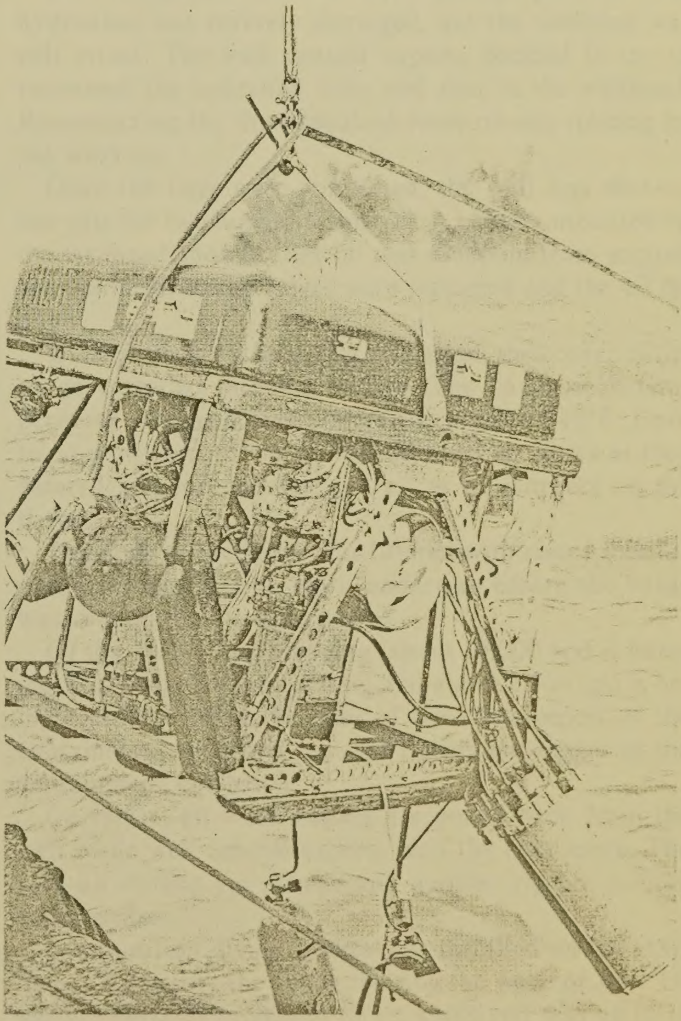
Response to the emergency. Some 30,000 bopd were spewing out of the well with half of it burning. About 12,000 ft of pipe, the rotary, traveling block and half the derrick were on the seabed near the wellhead.

Several tugs sailed into the flames to cut the anchor chains on the drilling rig so it could be towed away from the well.

Working with the Mexican diving firm Diavaz, Houston-based Martech International flew an unmanned submersible, the *TREC*, to the area onboard a plane provided by Pemex. The Houston company was alerted June 6 and had the unit in operation by noon, June 7. The manned submersible *Pioneer I* was also mobilized and a portable handling system was installed onboard the supply vessel *State Justice*.



DIVER PREPARES FOR WELLHEAD INSPECTION. A steady stream of water was poured over the divers as they entered and left the sea.



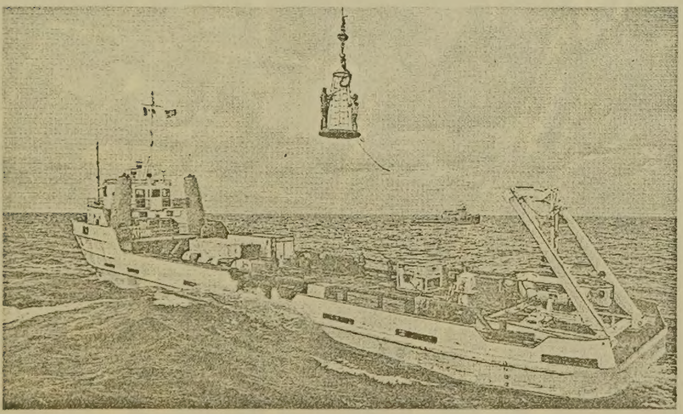
SUBMERSIBLE SURVIVES VORTEX. The force of the vortex over the wellhead can be seen in the damage to the unmanned submersible *TREC*. During inspection of the wellhead, the unit was "blown" to the surface after it was caught in the suction created by the escaping oil.

Two large oil spill containment booms and two oil recovery skimmers were flown from Norway to help in fighting the blowout. The skimmers were built by Frank Mohn A/S while the booms were supplied by A/S Nofi and by Norsk Oljelense A/S. The equipment is part of

Photographs courtesy of Martech International

SPILL RECOVERY OPERATIONS. Oil containment equipment was flown in from Norway.

REAL-TIME VIDEO INSPECTION. The two top Pemex men, left, and Red Adair, center, watch the video display of the wellhead as divers inspect the damage.



MANNED SUBMERSIBLE USED FOR SUPPORT. The manned submersible *Pioneer I* is installed on the supply boat *State Justice.* This is the first time a manned submersible has been used in support of well fighting operations.

the oil spill response equipment required by the Norwegian government.

Red Adair is the well-fighting consultant on the project.

Fighting the blowout. Every available vessel in the area was put to work by Pemex in fighting the blowout. The diving firms worked from the barge *Able Turtle.* The unmanned submersible was "flown" into the wellhead for close television examination of the wellhead. After 14 hours, the submersible found a safe way to approach the wellhead without being bothered by the vortex created by escaping oil.

During further examination of the wellhead, the submersible was caught in the vortex and blown to the surface. After it was recovered, operators found much of the equipment knocked loose from its mountings. However, they had enough spare parts to repair and put it back into service.

Divers followed the submersible's umbilical to the wellhead and used its lights for a close visual examination of the wellhead, says Rob Robertson, Martech. A videotape of the examination was made and shown to Jorge Diaz Serrano, director general of Pemex, and his top aides.

The inspection showed the control pod for the hydraulics was severely damaged, but the wellhead was still intact. The well control experts decided to try to reconnect the hydraulic lines and shut in the wellhead. Reconnecting the lines required some on-site splicing by the workers.

Once the lines were connected, the well was shut-in, but only for two hours on June 24. A camera mounted on the wellhead showed that oil was escaping from around the wellhead, so the valves were reopened and the oil ignited.

During much of the diving operation, the corner of the barge extended into the flames. The barge deck temperature on that corner climbed as high as 145°F. Continuous streams of water were sprayed on divers as they entered and left the sea as well as on workers on the barge.

The deck of the barge was littered with riser tubes for platform construction work underway before the barge was mobilized for well control.

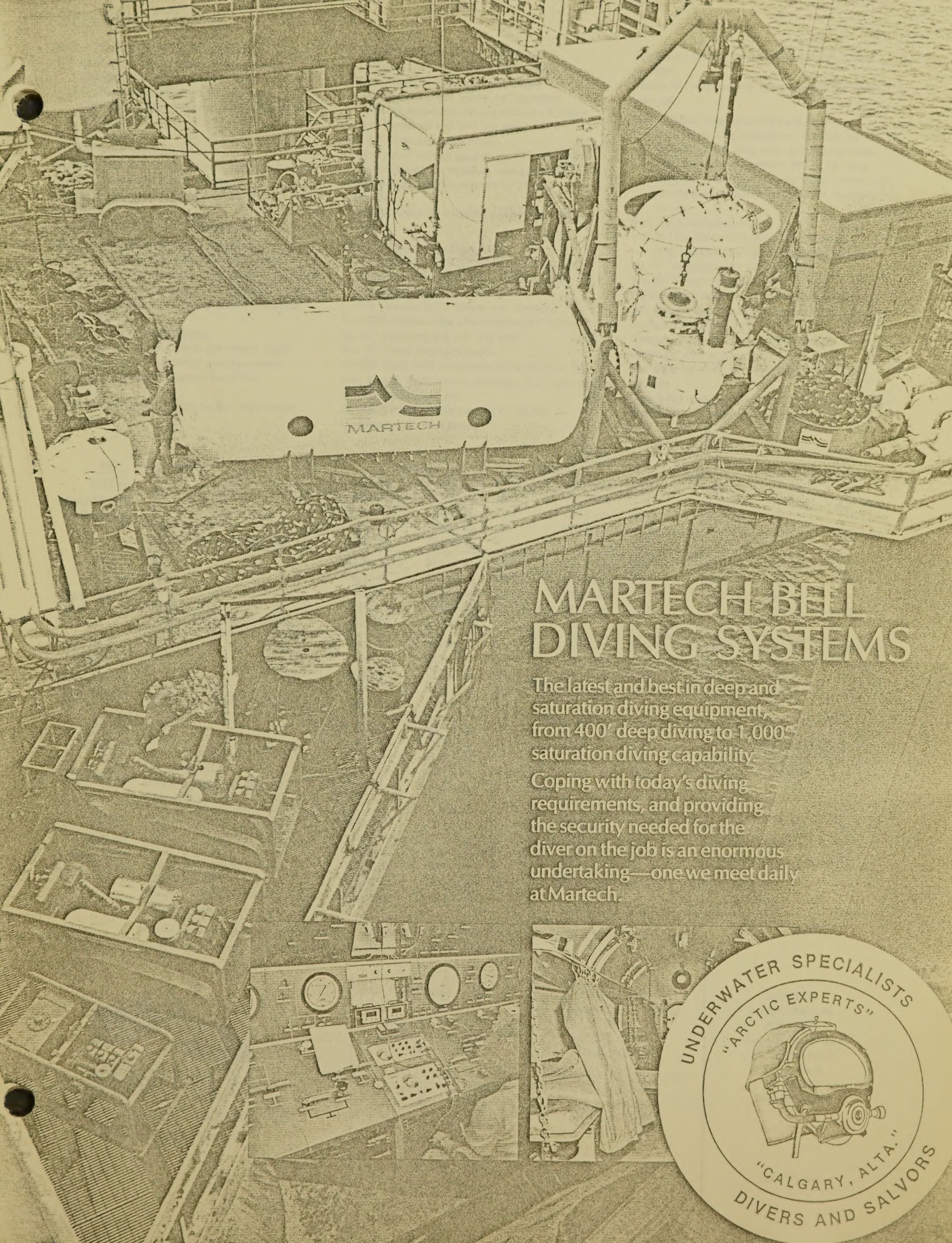
Of the 30,000 bpd escaping, about 15,000 bpd is burning, 12,500 bpd is evaporating and about 2,500 bpd is being recovered. One measure of the effectiveness of the containment system is that the flames got bigger as the containment got better.

Currently, all work vessels are pulled back from the well while well control experts plan the next move. The jack-up drilling rig *Azteca* and another rig are drilling relief wells.

A saturation diving system was installed on the *Able Turtle* for use by the divers. During the week of June 18, surface currents increased to 3½ knots and seas up to 10 ft. The divers were so tired from fighting currents that they were not as effective once they reached the wellhead. The saturation system would be able to lower the divers in a bell.

One problem caused by the increased current was greater mixing of the oil and water. When the well first blew out, the oil-water mix moved to the surface in a cone-shaped vortex above the well. As the currents increased, more oil was forced down around the wellhead, cutting visibility.

Pipelay and derrick barges used in the operation include the *Tolteca,* operated by a Mexican joint venture and the *L.B. Meaders* owned by Brown & Root.



MARTECH BELL DIVING SYSTEMS

The latest and best in deep and saturation diving equipment, from 400′ deep diving to 1,000′ saturation diving capability.

Coping with today's diving requirements, and providing the security needed for the diver on the job is an enormous undertaking—one we meet daily at Martech.

UNDERWATER SPECIALISTS
"ARCTIC EXPERTS"
"CALGARY, ALTA."
DIVERS AND SALVORS

SPECIFICATIONS

400′ (122m) Deep Diving Bell System

1 — Double Lock DDC (Deck Decompression Chamber) 60″ diameter × 12′ long
1 — TL (Transfer Lock) Sphere 48″ diameter
1 — SDC (Submersible Decompression Chamber) Diving Bell
Four 8″ Viewports
Two 90′ Diver excursion hoses
Control panel with all gas systems, lights, communications, O₂ monitors and flowmeters
Emergency gas and life support for 24 hrs.
Umbilical
Complete with hydraulic handling system

575′ (175.4m) Deep Diving Bell System

1 — Double Lock DDC (Deck Decompression Chamber) 60″ diameter × 12′ long
1 — TL (Transfer Lock) Sphere 48″ diameter
1 — SDC (Submersible Decompression Chamber)
Five 8″ Viewports
Two 90′ Diver excursion hoses
Control panel with all gauges, gas system, lights, communications, O₂ monitors and flowmeters
Emergency gas and life support for 36 hrs.
Umbilical
Complete hydraulic handling system with winch package

675′ (205.9m) Deep Diving Bell System

1 — Double Lock DDC (Deck Decompression Chamber) 60″ diameter × 12′ long
1 — TL (Transfer Lock) Sphere 48″ diameter
1 — SDC (Submersible Decompression Chamber)
Six 14″ Viewports and 1-8″ top port
Two 90′ Diver excursion hoses
Control panel with all gauges, gas systems, lights, communications, O₂ monitors and flowmeters
Emergency gas and life support for 36 hrs.
Umbilical
Complete hydraulic handling system with winch package

1000′ (305m) Deep Diving Bell

2 — Double Lock DDC's (Deck Decompression Chambers) 60″ diameter × 12′ long with sanitation facilities.
1 — TL (Transfer Lock) Sphere 60″ diameter
1 — SDC (Submersible Decompression Chamber)
Six 16″ Viewports and 1-8″ top port
Two 90′ Diver excursion hoses
Control shack with all controls to the gas fluid system, gauges, lights, communications, ECU units and monitors, scrubbers, etc.
Emergency gas and life support for 36 hrs.
Umbilical with stowage sub
Complete hydraulic handling system with winch package
Diver's hot water system, complete with hot water suits, etc.

1000′ (305m) Saturation Diving System

1 — DDC (Deck Decompression Chamber) 60″ diameter × 12′ long with sanitation facilities
1 — DDC (Saturation Chamber) 84″ × 20′ long, complete with ECU (Environmental control unit) for positive control of temperatures, humidity, O₂, etc.
Bunk for 6 saturation divers
1 — TL (Transfer Lock) Sphere 60″ diameter
1 — SDC (Submersible Decompression Chamber)
Six 16″ Viewports with 1-8″ top port
Two 90′ Diver excursion hoses
Control shack with all controls to the gas fluid system, gauges, lights, communications, ECU units and monitors, scrubbers, etc.
Emergency gas and life support for 36 hrs.
Umbilical with stowage sub
Complete hydraulic handling system with winch package
Diver's hot water unit and a steam back-up unit complete with suits, hoses, connectors, etc.

	Component	WEIGHT		HEIGHT		WIDTH		LENGTH	
400′ (122 m) Deep Diving Bell System	SDC	5500 lbs.	2494.7 kg	8′8″	264.1 cm	5′6″	167.6 cm	54″ ID	137.1 cm
	DDC	7800 lbs.	3538.0 kg	5′9″	175.2 cm	5′4″	162.5 cm	14′3″	434.3 cm
	TL	2500 lbs.	1134.0 kg	5′11″	180.3 cm	4′7″	139.7 cm	48′	121.9 cm
	Handling System	15000 lbs.	680.4 kg	22′	670.5 cm	10′8″	325.1 cm	21′6″	655.3 cm
	Winch & Hydraulic Package	9800 lbs.	4445.2 kg						
575′ (175.4 m) Deep Diving Bell System	SDC	5500 lbs.	2494.7 kg	8′8″	264.1 cm	5′6″	167.6 cm	54″ ID	137.1 cm
	DDC	7800 lbs.	3538.0 kg	5′9″	175.2 cm	5′4″	162.5 cm	14′3″	434.3 cm
	TL	2500 lbs.	1134.0 kg	5′11″	180.3 cm	4′7″	139.7 cm	48″	121.9 cm
	Handling System	15000 lbs.	680.4 kg	22′	670.5 cm	10′8″	325.1 cm	21′6″	365.7 cm
	Winch & Hydraulic Package	9800 lbs.	4445.2 kg						
675′ (205.9 m) Deep Diving Bell System	SDC	5580 lbs.	2531.0 kg	8′	243.8 cm	7′10″	238.7 cm	72″ ID	182.9 cm
	DDC	11800 lbs.	5352.4 kg	5′11″	180.3 cm	5′8″	172.7 cm	14′3″	434.3 cm
	TL	3100 lbs.	1351.3 kg	6′	182.9 cm	5′6″	167.6 cm	48″	121.9 cm
	Handling System	15000 lbs.	6803.9 kg	22′6″	670.5 cm	10′8″	325.1 cm	21′6″	55.3 cm
	Winch & Hydraulic Package	9800 lbs.	4445.2 kg						
1000′ (305 m) Deep Diving Bell	SDC	6800 lbs.	3084.4 kg	8′	243.8 cm	7′10″	238.7 cm	72″ ID	182.9 cm
	DDC	15600 lbs.	7076.0 kg	5′11″	180.3 cm	5′8″	172.7 cm	14′3″	434.3 cm
	TL	5200 lbs.	2358.7 kg	6′	182.9 cm	5′6″	167.6 cm	60″	152.4 cm
	Handling System	15000 lbs.	6803.9 kg	22′6″	670.5 cm	10′8″	325.1 cm	21′6″	655.3 cm
	Winch & Hydraulic Package	9800 lbs.	4445.2 kg						
	Control Shack			9′	274.3 cm	6′	182.9 cm	8′	243.8 cm
1000′ (305 m) Saturation Diving System	SDC	6800 lbs.	3084.4 kg	8′	243.8 cm	7′10″	238.7 cm	72″ ID	182.9 cm
	DDC	15600 lbs.	7076.0 kg	5′11″	180.3 cm	5′8″	172.7 cm	14′3″	434.3 cm
	TL	5200 lbs.	2358.7 kg	6′	182.9 cm	5′6″	167.6 cm	60″	152.4 cm
	Saturation Chamber (6 men)	32000 lbs.	1451.5 kg	8′	243.8 cm	8′	243.8 cm	20′	609.6 cm
	Handling System	15000 lbs.	6803.9 kg	22′6″	670.5 cm	10′8″	325.1 cm	21′6″	655.3 cm
	Winch & Hydraulic Package	9800 lbs.	4445.2 kg						
	Control Shack			9′	274.3 cm	8′	243.8 cm	12′	365.7 cm

SDC — Submersible Decompression Chamber **DDC** — Deck Decompression Chamber **TL** — Transfer Lock Chamber

Coded—All pressure vessels are stamped by ASME and USCG approval.

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Litho in U.S.A.

The Martech Reel Barge ENTERPRISE is the most cost/effective means available today of laying pipe in 50′ to 1200′+ depths of water.

The unique, patented vertical reel and special pipe-straightening apparatus enable the reel barge to lay as much pipe in one hour as a conventional stovepipe barge can lay in 24 hours. Faster pipelaying means greatly reduced weather exposure and overall operating costs including inspection diving time. Think about that the next time your standby time due to bad weather has equalled or exceeded your productive time on offshore pipelaying jobs.

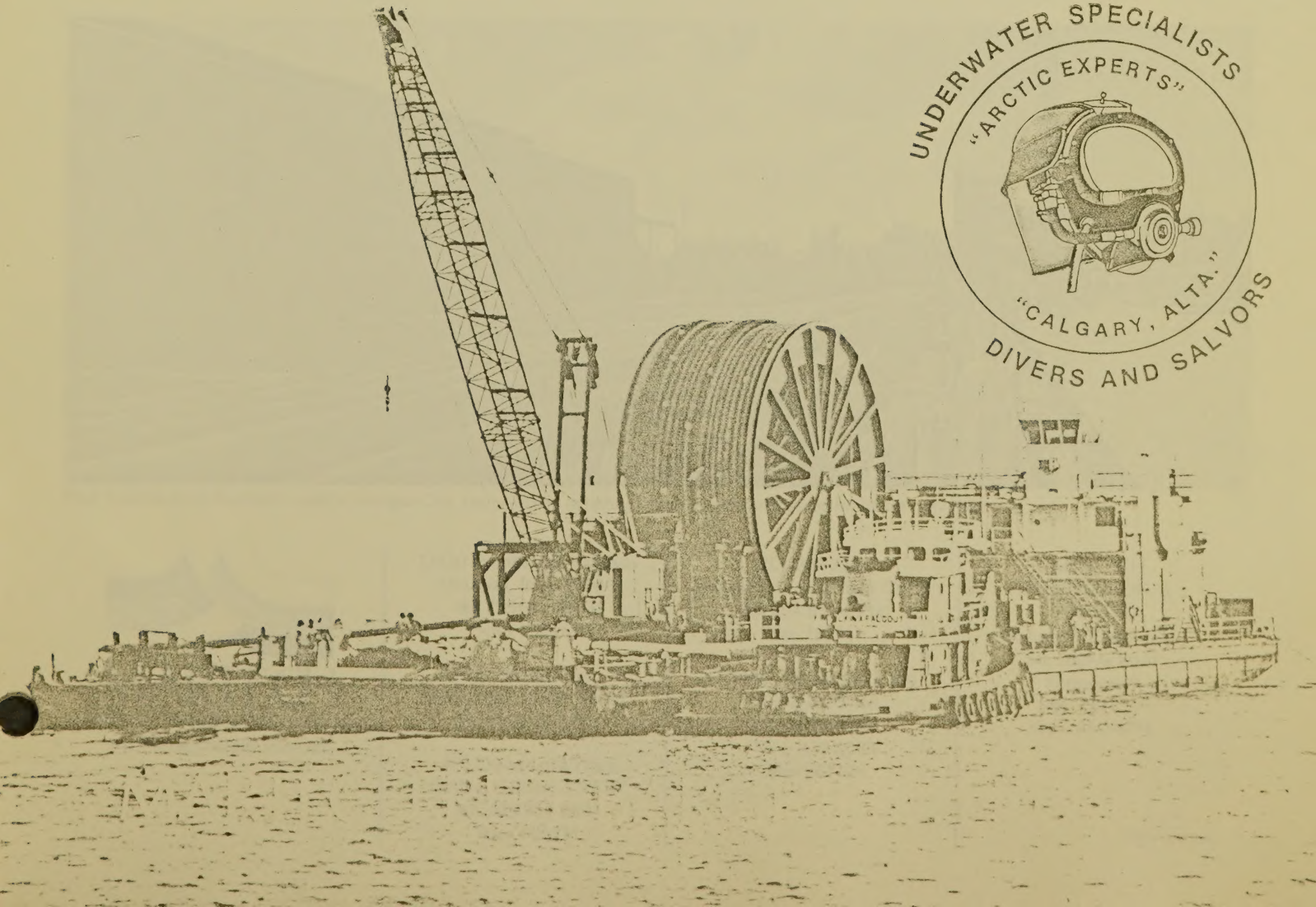
Here's how it works:

All pipe is welded into strings and x-ray inspected at our onshore pipe yard. By eliminating conventional offshore handling and welding of the pipe, exposure to damage is minimized and quality control is greatly improved.

After being joined at the yard, the pipe is spooled onto the reel aboard the barge and towed to the job site. Unlike conventional lay barges, the ENTERPRISE does not utilize anchor winches while laying pipe. After being secured at one end, the pipe is laid under tension while the barge is under tow. As the pipeline comes off the reel, Martech's unique, patented pipe straightening apparatus takes over. This consists of a series of vertical and horizontal rollers strategically spaced to straighten the pipe.

Damage to the pipe is prevented by the design of the rollers and their thick, protective rubber coating. Pipeline can be laid in any water depth from 8′ to 2,000′ by adjusting the position of the reel on the barge

The entire operation is performed rapidly and efficiently, making the ENTERPRISE the most efficient method you'll find for offshore pipelaying.



UNDERWATER SPECIALISTS
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DIVERS AND SALVORS

SPECIFICATIONS

REEL BARGE

- 44-man on-deck air conditioned quarters and galley
- ABS and USCG approved — Manned Status
- Dimensions: 240′ × 72′ × 14′
- Four-point anchor spread, tower controlled, T.V. monitored
- Crane: Manitowoc — 4000 W — 150-ton capacity
- Heliport: 40′ diameter
- Fuel capacity: 77,000 gals.
- Fresh water capacity: 77,000 gals.

STANDARD EQUIPMENT

6 ea. Welding machines

1 ea. Hydraulic power unit

1 ea. Air compressor — 705 cfm

2 ea. Generators — 135 kw ea.

1 ea. Test pump

REEL

Reel Flange diameter: 44 ft.

Reel Core diameter: 32 ft.

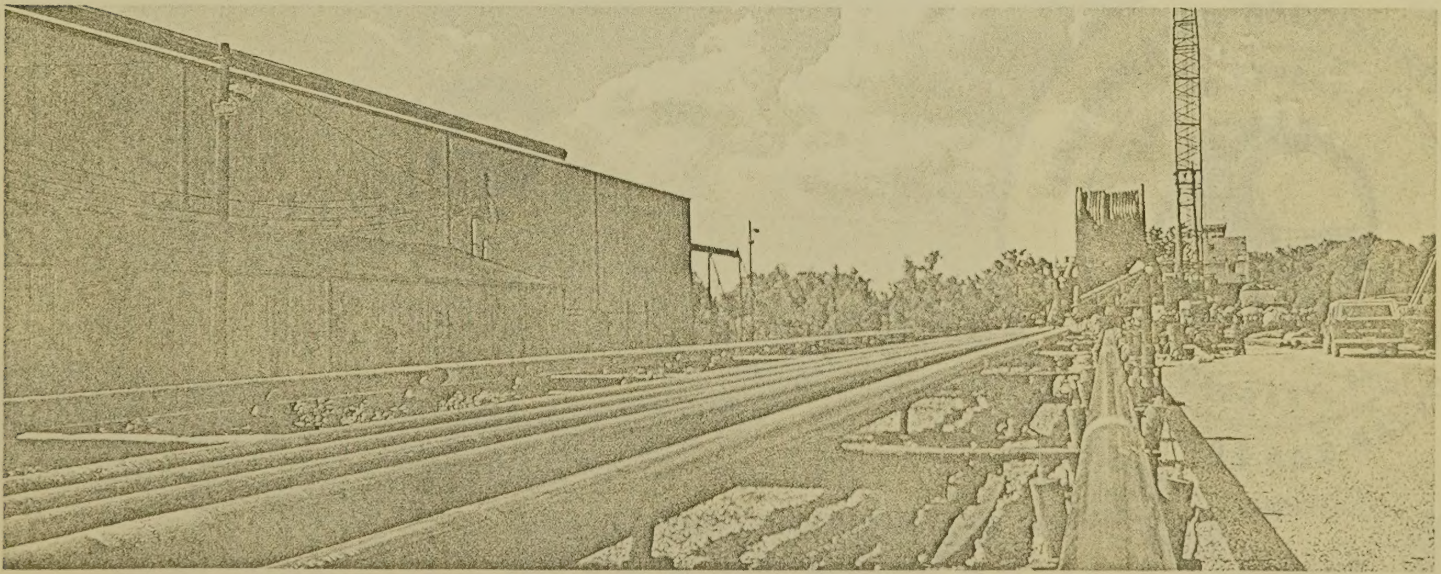
Spread between Reel flanges: 18 ft.

REEL CAPACITY

Pipeline Size		Length	
Inches	Centimeters	Feet	Meters
10	25.4	12,000	3657.6
8	20.3	20,000	6096.0
6	15.2	30,000	9144.0
4	10.2	65,000	19812.0
2	5.1	200,000	60960.0

LIFTING CRANE CAPACITIES

Boom						Ctwt. "A"				Ctwt. "AB"	
	Radius		Angle	Boom Point Height		With Boom Live Mast & 1¼" (31.75 mm) Dia. Boom Pendants		Without Boom Live Mast & With 1½" (38.10 mm) Dia. Boom Pendants		With Boom Live Mast & 1¼" (31.75 mm) Dia. Boom Pendants	
Length	Feet	Meters	Degree	Feet	Meters	Pounds	Kilograms	Pounds	Kilograms	Pounds	Kilograms
90′ (27.43 m)	19	5.79	80.8	95′ 7″	29.13	107,500	48,762	102,400	46,449	145,400	65,953
	20	6.10	80.1	95′ 5″	29.08	98,600	44,725	93,900	42,593	143,700	65,182
	25	7.62	76.9	94′ 5″	28.78	69,400	31,480	66,100	29,983	102,800	46,630
	30	9.14	73.6	93′ 1″	28.37	53,100	24,086	50,600	22,952	79,100	35,880
	35	10.67	70.2	91′ 5″	27.86	42,700	19,369	40,600	18,416	64,000	29,030
	40	12.19	66.8	89′ 6″	27.28	35,400	16,057	33,700	15,286	53,500	24,268
	50	15.24	59.7	84′ 5″	25.73	26,000	11,794	24,800	11,249	39,900	18,099
	60	18.29	52.0	77′ 8″	23.67	20,200	9,163	19,200	8,709	31,400	14,243
	70	21.34	43.4	68′ 7″	20.90	16,200	7,348	15,500	7,031	25,600	11,612
	80	24.38	33.1	55′ 10″	17.02	13,200	5,988	12,700	5,761	21,400	9,707
	90	27.43	18.4	35′ 1″	10.69	11,000	4,990	10,700	4,854	18,100	8,210



Pipe is received at Martech's yard in Morgan City, Louisiana, in lengths of 40 ft., joined and stored for future operations.

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MARTECH REMOTE CONTROLLED VEHICLES

MARTECH INTERNATIONAL'S REMOTE-CONTROLLED TELEVISION VEHICLES are used for surface-directed subsea inspection at depths to 6,000'+. *Equipped with a low light level SIT TV camera*, miniaturized and encased in a syntactic foam hull, these inspection vehicles can remain on station underwater indefinitely.

The pitching lens assembly of the SIT camera allows remote variation of the viewing angle of ±90° from horizontal. Illumination from two 45-watt tungsten halogen lamps allows viewing to 30 feet in the absence of ambient light. Adjustment of the light reflectors will provide optimum viewing in clear or turbid water.

THE VEHICLES OFFER REMARKABLE MANEUVERABILITY in currents to 1 knot. Four oil-filled motors give the vehicle three degrees of freedom in translation (fore/aft, port/starboard, up/down) and one degree of freedom in heading rotation.

THE SINGLE-ELEMENT CONTROL STATION incorporates all controls and monitoring devices into one location. The vehicle operator, acting independently or on instruction from others, can direct the vehicle to any desired position. A one-hand, fully proportioned joy-stick 'steers' the vehicle. Depth and heading are automatically maintained by servo-controls. Depth, heading and lens pitch angle are displayed on the TV monitor and become a permanent part of the video tape record.

THE VEHICLE IS DEPLOYED in a protective launching cage enclosing a tether cable winch. The cage is lowered to working depth by a skid-mounted hydraulic winch and A-frame assembly. At depth, the vehicle flies from the cage to inspect, and is retrieved for return to the surface.

THE OBLATE SPHEROID HULL OF THE VEHICLE is ideally designed for high maneuverability in any subsea environment. The high strength, positively buoyant tether cable contributes to this maneuverability. The tether cage winch provides protection for the cable from entanglement or damage.

ITS ENDURANCE LIMITED ONLY BY THAT OF THE SURFACE OPERATOR, the Martech remote-controlled vehicle is the ideal tool for subsea inspection work.

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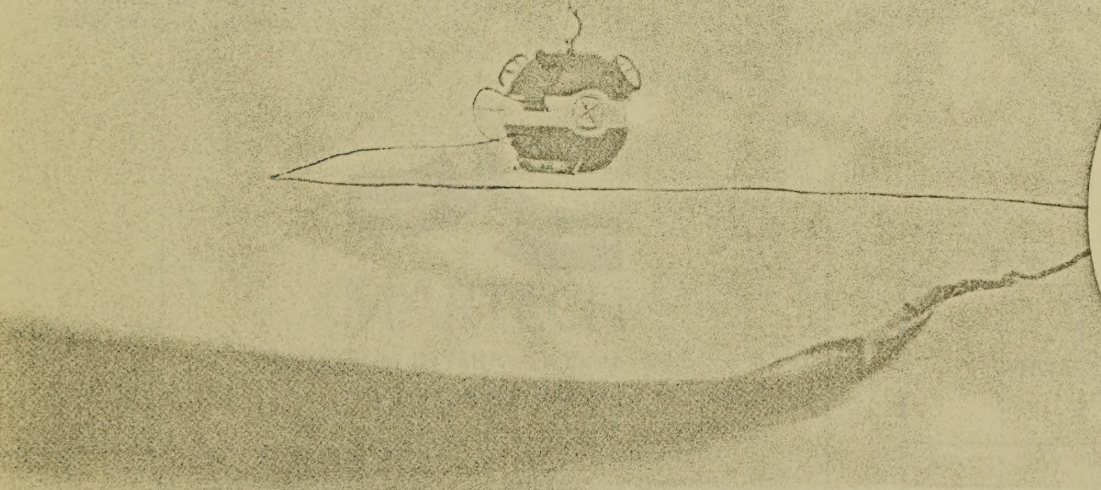
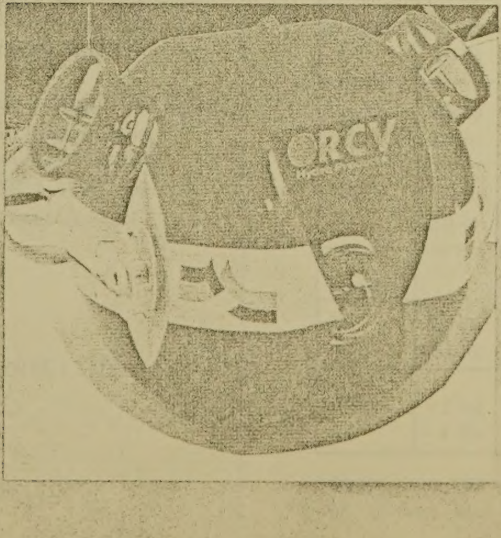
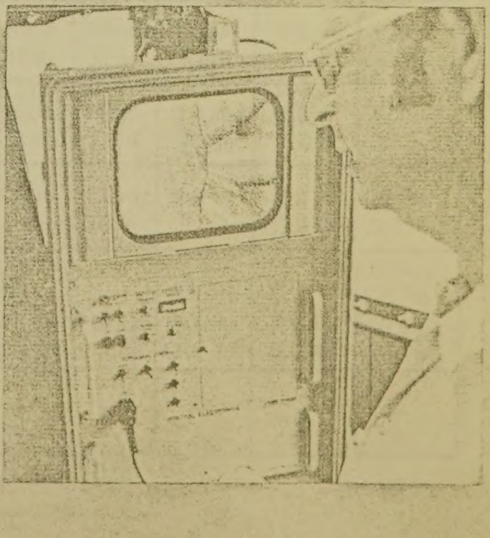






SPECIFICATIONS

VEHICLE

Maximum Operating Depth: 2000 meters (6600 feet)
Maximum Operating Current: 1 knot
Viewing Range: 7-10 meters (23-33 feet) Clear water, no ambient light
Speed: Forward — 1.0 knot. Reverse — .85 knot. Port/Starboard — .85 knot. Up/Down — 0.5 knot. CW/CCW Rotation — 180°/sec
Working Strength of Buoyant Tether Cable: 454 kg (1000 lbs)
Location and Recovery Devices: Acoustic pinger, strobe flasher, tether cable cutter

CONTROL STATION

CONTROL/DISPLAY UNIT
Displays: Video-annotated with depth, relative heading and lens pitch angle, number and direction of cable twists, tether cable payout, elapsed time
Vehicle Propulsion Remote Controls: Proportional translation forward/reverse, left/right, and heading rotation CW/CCW — Automatic depth and heading control with manual backup
Television Camera Remote Controls: Lens pitch angle, lens focus
Deployment Controls: Launcher lock, tether cable winch, tether cable cutter

POWER SUPPLY
Input Power: 220 VAC — 3 ϕ — 50 to 60 HZ or 440 VAC — 3ϕ 50 to 60 HZ (5 kw maximum)

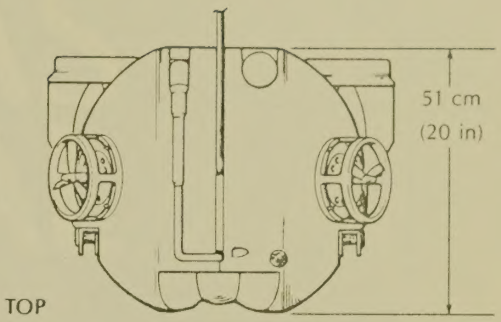
DEPLOYMENT UNIT

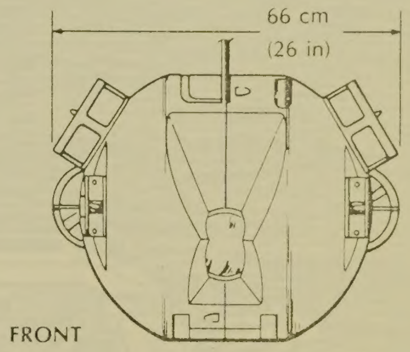
WINCH/SKID/A-FRAME
Armored cable capacity: 400 meters (1350 feet) Higher capacity winches available for greater depths
Armored cable winch rate: Variable from 0 to 36 m/min (120 ft/min)
Armored cable winch maximum pull: 907 kg (2000 lbs)

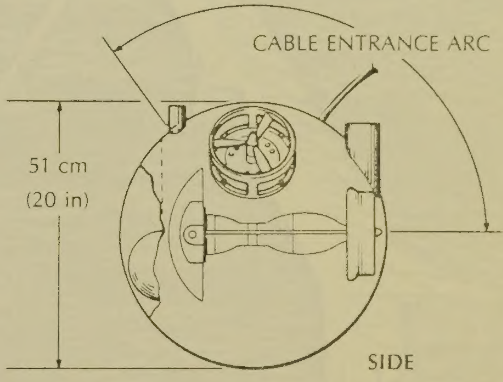
HYDRAULIC POWER SUPPLY
Input Power: 220 VAC — 3ϕ — 50 to 60 HZ or 440 VAC — 3ϕ — 50 to 60 H (15 kw maximum)

LAUNCHER
Tether cable capacity: 120 meters (400 ft)
Tether cable winch rate: 18 m/min (60 ft/min)
Tether cable winch maximum pull: 23 kg (50 lbs)

Martech video tape recordings may be reviewed and analyzed in controlled office environments.







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RCV-225 SYSTEM SIZE AND WEIGHT

		CONTROL STATION		DEPLOYMENT UNIT		
	Vehicle	Control Display	Power Supply	Winch Skid A-Frame	Hydraulic Power Supply	Launcher
Location	U/W	Topside	Topside	Topside	Topside	U/W
Height	51cm 20 in	80cm 31 in	80cm 31 in	1.8m 6.0 ft	0.8 m 2.5 ft	1.1 m 3.7 ft
Width	66cm 26 in	56cm 22 in	56cm 22 in	1.4 m 4.5 ft	0.6 m 2.0 ft	1.0 m 3.2 ft
Depth	51cm 20 in	78cm 30 in	78cm 30 in	2.3 m 7.5 ft	0.9 m 3.0 ft	1.0 m 3.2 ft
Weight Air	82 kg 180 lbs	172 kg 380 lbs	158 kg 350 lbs	1900 kg 4200 lbs	180 kg 400 lbs	80 kg[1] 175 lbs 64 kg[2] 140 lbs
Water	−2 kg −4 lbs	— —	— —	— —	— —	— —

[1] With 400 meters (1350 feet) armored cable.

[2] With 120 meters (400 ft) tether cable.

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February 13, 1978

OIL & GAS JOURNAL

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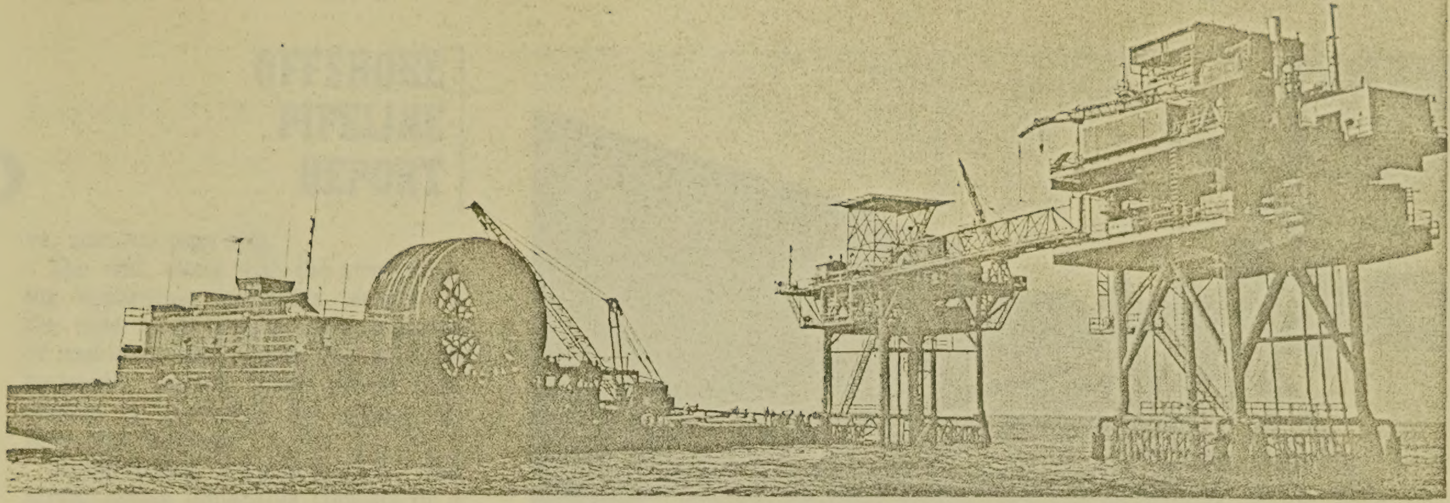
OFFSHORE PIPELINE REPORT . . . 55



REEL BARGE Martech Enterprise has vertical reel and a special straightening apparatus (Fig. 1).

Offshore pipe barge uses vertical reel

M. Cart
Martech International, Inc.
Morgan City, La.

THREATS of foul weather are always present in offshore pipelaying projects. During winter months, standby time due to poor weather often equals or exceeds time spent in productive operations.

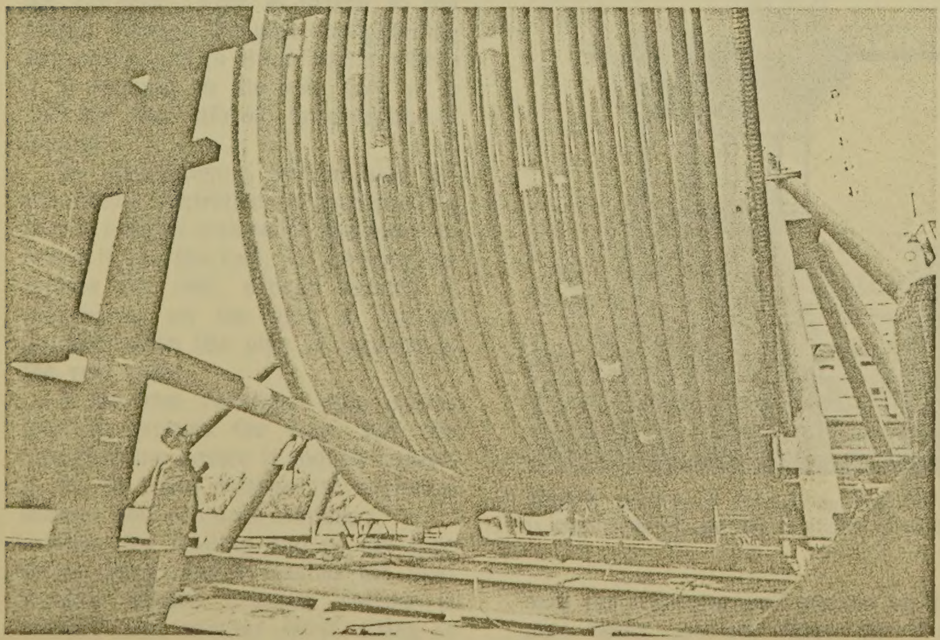
Although enclosing structures has made it easier to cope with hostile environments, this approach is unsuitable for offshore pipeline construction since large areas must be traversed and a water interface must be considered.

Construction systems, therefore, must make the best use of fair weather periods. Equipment must also be designed to be less weather-sensitive.

With these parameters, Martech International Inc., determined after evaluating conventional offshore pipe-laying methods that reel-barge pipe-laying offered advantages due to its reduced offshore exposure time and higher laying speed.

It was calculated that a reel barge could lay as much pipe in 1 hr as a conventional stovepipe method of equal size could lay in a day.

As a result of these studies, the reel barge Martech Enterprise (Fig. 1) was built for offshore deepwater pipelaying. It is 240 ft long by 72 ft wide and has a depth of 14 ft. It is U.S. Coast Guard approved for all oceans and is American Bureau of Shipping approved with a Maltese cross, A-1 ocean load-line rating for a manned barge.



VERTICAL reel offers flexibility for handling various pipe sizes, wall thicknesses, water depths, and sea conditions (Fig. 2).

Quarters and galley capacity of the Enterprise is 44 men. Twenty-five men operate the barge and additional facilities can accommodate another 19 persons including inspectors, testers, and divers. The barge has a fuel capacity of 77,000 gal plus an equal capacity for water ballast.

Lifting is provided by a 110-ton crane which can be relocated on the barge for flexibility. Mooring is provided through a four-point anchoring system with tower control.

Key features. These facilities and equipment are common to many conventional pipelaying barges. Key features which differentiate the Enterprise from other lay barges are its vertical reel and a special pipe-straightening apparatus.

These patented devices are mobile with respect to the barge deck and each other and offer maximum flexibility for handling various pipe sizes, wall thicknesses, water depths, and sea conditions.

Each movement of the straightener/reel system changes the profile view of the barge. The reel's hydraulically driven system makes it a self-loading storage facility for pipe as it is wound around the core.

The reel itself (Fig. 2) has a flange diameter of 44 ft and a core diameter of 32 ft with a spread of 18 ft between flanges. Table 1 shows its capacity

Table 1

Reeling capacity

Nominal pipe diameter, in.	Capacity, ft
10	12,000
8	20,000
6	30,000
4	65,000
2	200,000

vs. nominal pipe size.

The reel, along with the straightening apparatus, maintains tension on the pipe as it is laid using a series of regulators and bypass valves in the hydraulic system. When preset pipe tension is exceeded, the system allows pipe slippage.

Straightening equipment. The straightening apparatus consists of a series of vertical and horizontal rollers strategically spaced to straighten and relieve stress in the pipe. This system relieves stresses in all planes and eliminates the helical configuration of the pipe due to spooling. The diameter of the straightening rollers and a thick rubber surface coating prevent damage to pipe coatings.

Preliminary operations. As a component part of the reel-barge-laying system, Martech maintains a pipe yard at Morgan City, La., (Fig. 3). Pipe is received in double random lengths of about 40 ft, joined together, and stored for future loadings in 440-ft lengths. Work is now under way to extend this 440-ft length for greater flexibility.

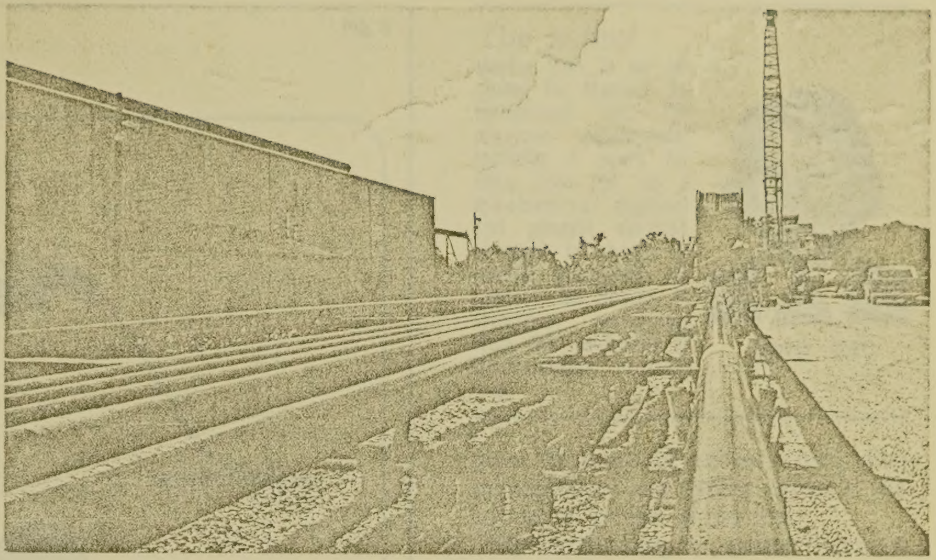
Joining the pipe onshore enhances weld quality (Fig. 4) eliminating wind, rain, sea spray, pitch, and yaw.

Each joint is X-rayed and coated before storing. Interfacing of onshore operations and offshore equipment occurs when the reel barge arrives at the pipe yard. The barge is positioned with its stern to the pipe conveyor so that the spool flanges are equidistant from the center line of the conveyor. Pipe is driven to the barge, through the pipe straightening apparatus, and to either flange where it is secured to the reel core in a manner that allows articulation of joining.

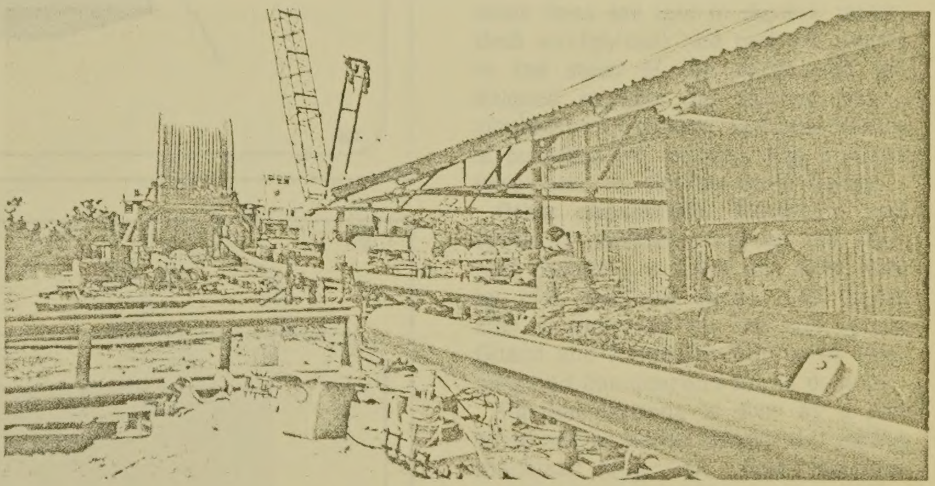
The straightening device, also hydraulically controlled, is positioned so that it creates tension on the pipe between it and the reel. As the operator rotates the reel, enough tension is maintained on the pipe to initiate bending when the pipe is tangent to the reel core.

As the reel revolves, pipe moves laterally across the core and the straightening device is moved laterally by an equal distance to maintain tension and compact loading.

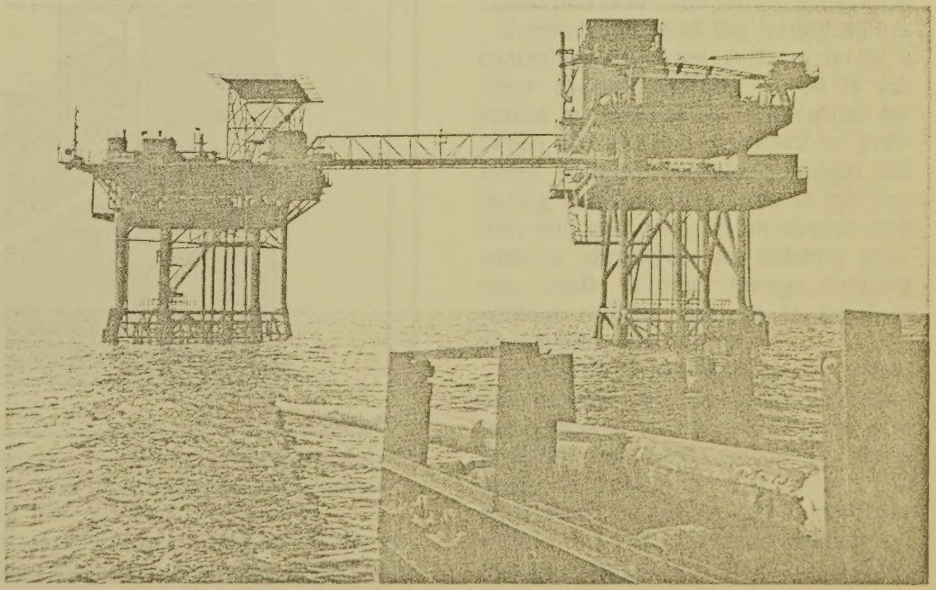
When the trailing end of the pipe string being loaded reaches the final welding station onshore, reeling is stopped and another 440-ft string is rolled out of an adjacent storage rack onto the conveyor and welded to the pipe being spooled. After the final weld is made, the joint is X-rayed, accepted, and coated. Spooling continues until the amount of pipe needed is loaded.



PIPE is received at pipe yard in Morgan City, La., in double lengths of 40 ft, joined, and stored for future reel loadings (Fig. 3).



JOINING pipe onshore enhances welding conditions by eliminating wind, rain, sea spray, and pitch and yaw of the carrier (Fig. 4).



PROPER curvature of the pipe between the point where it leaves the barge and the water surface is maintained by applying rotational force opposite the direction of the reel (Fig. 5).

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Fig. 6

Pipelaying methods

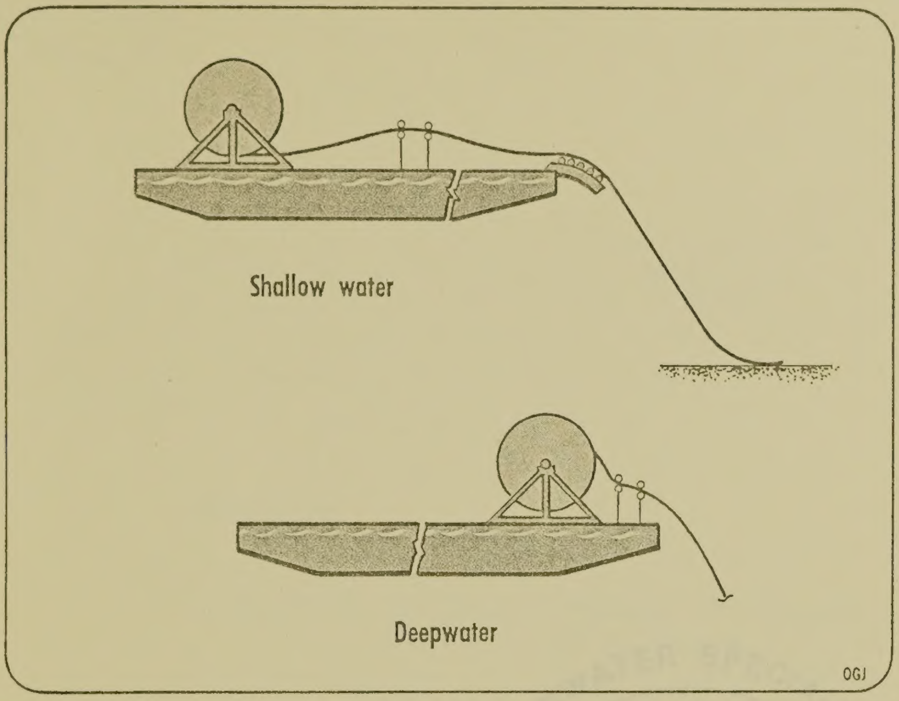
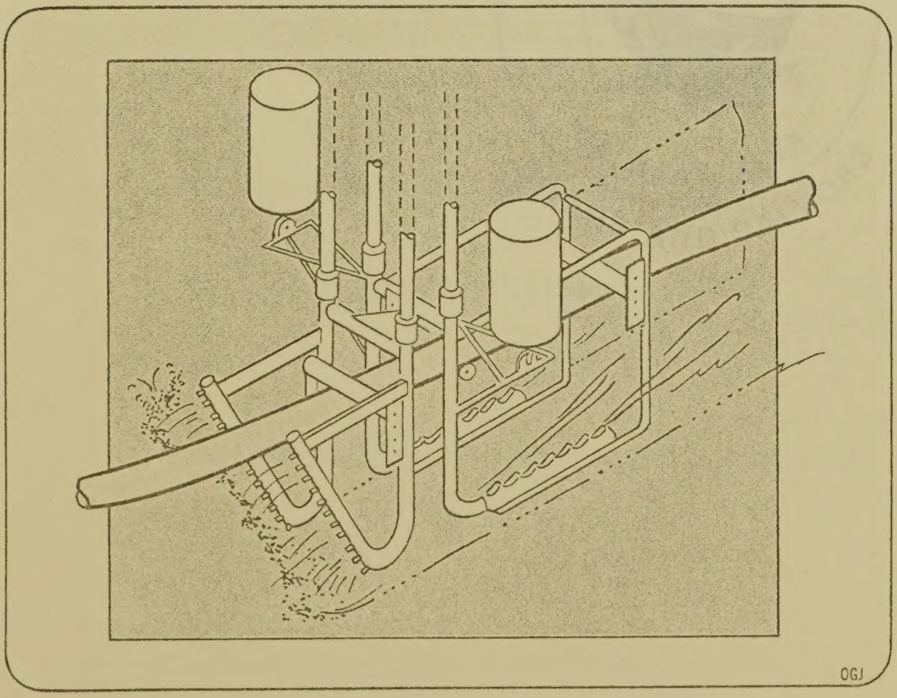


Fig. 7

Jet sled



The author . . .

Martin Cart is an engineer for Martech International Inc. His previous employment includes 7 years for Data Com Inc. as a mechanical engineer and general services manager in charge of marine operations. He holds a BS degree in industrial technology from the University of Southwestern Louisiana.

Martin Cart

Different sizes, lengths, and wall thicknesses of pipe can be loaded and stored on the reel at the same time.

After loading is complete, the barge is towed to the offshore location. At location, a pipe end is secured to a stationary object (platform) where the pipeline is to be terminated. After securing the pipe end, the barge is towed along a selected course to the opposite line terminal. While under tow, line pipe is pulled from the reel and lowered into the water.

Rotational force is applied in the opposite direction of the reel to maintain proper catenary of the pipe between the point where it leaves the barge (Fig. 5) and the contact point on the seafloor. This counter-rotational force is less than the force of the tug towing the reel barge, but is great enough to maintain constant tension on the pipe. The constant tension is controlled by regulators and bypass valves in the hydraulic system of the reel.

By maintaining a pipeline catenary by applying tension, no stinger is needed to support the line through the top curve of the compound catenary when lines are laid in shallow water. Both straightener and reel are moved to the stern of the barge and positioned so that the pipeline has a single-curve catenary and possibilities of buckling are reduced. Fig. 6 shows deepwater vs. shallow-water laying.

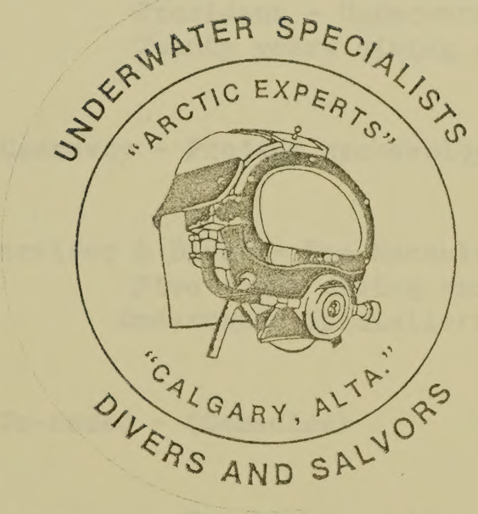
Other capabilities. Martech's reel barge is complemented by the Martech Hustler, a 210-ft by 50-ft wide by 14-ft deep jet barge. This barge also is approved by the U.S. Coast Guard and American Bureau of Shipping and has quarters for 44 persons.

Pipeline burying is done by a patented self-propelled underwater jetting machine (Fig. 7). This machine straddles the pipeline and removes seabed material from below the line with 1,000 psi jets of water directed ahead and below the jetting apparatus.

Forward speed of the jetting unit is controlled from the surface or by a diver at the machine. Speed is adjusted by varying the differential between forward and rearward jet pressures. With this propulsion system, the jetting unit has little force or momentum and can come to an abrupt stop when it encounters an existing pipeline, cable, or other foreign crossing without causing damage to itself or an existing installation.

Seawater is provided to the jetting unit through two, five-stage Worthington pumps at a rate of 2,000 gpm at a pressure of 1,250 psi/pump. Each pump is driven by a 2,100-hp, V-16 Alco diesel engine. A speed increaser with a 1:4 ratio between engine and pump is used to turn the pump at 3,500 rpm.

This barge also is equipped with a tower-controlled, four-point anchoring system. It contains offshore firefighting equipment, a 50-ton crawler crane, and welding capabilities for conventional pipelaying. END



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"ARCTIC EXPERTS"
"CALGARY, ALTA."
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Inuvik - 979-3268
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24 Hour Service

533 - 11 Avenue S.W.
Calgary, Alberta
T2R 0C9

PERSONNEL

1. H. W. R. Jackson - Project co-ordinator (Canadian) and Consultant.
   President - Underwater Specialists Ltd.
   Twenty years diving supervisory experience.

2. Kenneth A. Cassavoy - Project archaeologist (Canadian)

3. Project Supervisor & Diver - Don Macaulay (Canadian)
   Five years diving and project supervisor -
   Underwater Specialists Ltd.

4. Diver #2 - Un-named - (Canadian)

5. Trec Superintendent - Pat Hickey - (Canadian)
   Several years experience with Martech as
   Trec Superintendent and Submersible pilot.

6. Trec Technician - Un-named - (Canadian - if possible).

MARTECH

RESUME
of
John PATRICK Francis Hickey

Age: 23

Education:

1962 to 1971. Attended primary (Our Lady of the Rosary) and secondary (St. Joseph's College, Gregory Terrace) school in Brisbane, Australia.

1971. Attended Singapore International School for one year.

1972 to 1974. Transferred to the Singapore American School where I graduated with the Class of 1974. Subjects which included 2nd year Electronics, Computer Science and Programming. In 1973-4 I assisted Professional Scuba Instructor, Mr. J. P. Steen (P.A.D.I. M-3059), in all phases of training and aided in the maintenance of equipment.

1974. Enrolled in the General Arts and Science Course at Mount Royal College, Calgary, Alberta, Canada.

June, 1975. Enrolled at the Commercial Diving Center, Wilmington, California, U. S. A., in the Air/Mixed Gas Course #1 and Basic Underwater Photography/Television Course #3.

Experience:

Summer 1971. Worked for E. G. & G. Geophysical. Aided in setting up of Branch Office shop facilities. I worked as a part-time employee. Experienced in set-up and operations of sub-sea seismographic equipment to include side scan sonars, boomer/sparker sub-bottom profilers and Motorola positioning equipment. Worked off of work boats, supply boats, barges and bottom supported exploration platforms.

Summer 1973. Worked for Broman Divers International which was purchased by Oceaneering International. This work involved servicing recompression chambers, high and low pressure air compressors, diving hoses and lightweight Aquadyne masks.

Summer 1974. Worked for Brown and Root International in Labuan Fabrication Yard, Sabah, Malaysia. Material man working with local residents in shipping and receiving of materials which included heavy steel such as pipes, beams, sheet metal and gratings for fabrication of bottom supported station stationary jacket platforms and barge supplies. Some travel involved.

MARTECH
INTERNATIONAL INC
Marine technology in depth

13550 Hempstead Highway
Houston, Texas 77040
(713) 462-0010
Telex 790163

(Experience cont)
September - December, 1974. Part time employee with Woodwards Stores, Ltd. of Canada at Calgary, Alberta in the Display Department.

September - December, 1974. Part time employee with the City of Calgary Recreation Department (Employee No. 37346) at the Christ Church Community Center as a Youth Activity Leader.

January - April, 1975. Full time employee with Saskatoon Fire Engine Co. in Calgary with the Finishing Department. Prepared trucks for final painting, wiring, plumbing and installation of pumps, also installation of fire engine accessories.

October, 1975 to January, 1976. Worked for the Horton Maritime Explorations on submersible Auguste Piccard. Exterior hull wiring and fittings.

January, 1976 to July, 1976. Hyco Subsea Ltd. Trainee Pilot/Maintainer. Piloting experience on Aquarius I, Pisces VI, Pisces XI. Refitted Aquarius I. Participated on sea trial teams for Aquarius I and Pisces VI. Barge engineer Pisces VI sea trials.

September, 1976 to May, 1977. Underwater Specialists, Division of Formalog Ltd. Diver. November 1976 promoted to diver foreman/supervisor. In charge of crew operations in Canada and Arctic. Consisting of pipeline water crossing inspections, dredging, construction, video inspections, service and inspections on water intake screens for hydro electric and processing plants. Also experience in under ice diving and variable volume dry suits and Arctic winter diving conditions.

July 1977 to December 1977. Rigger and Driller for Flite Drilling Services. Working with TH-70, T H-100 and Carrie Truck mounted land drills.

January 1978. Martech International. Pilot on PC-14C Submersible,qualified RS-7 Operator, experienced with setup and operations on RCV-225 and Trec, experience with set up of all video gear including edits and minor troubleshooting.

Miscellaneous:

Certified B. S. - A. C. 3rd Class Diver.
Certified P.A.D.I. Divemaster.
Certified N.A.U.I. Advanced Diver.
Proficient in low visibility diving, deep water diving (185'x), night diving navigation u/w, wreck diving, search and recovery/search and rescue situations.
Some welding and cutting experience.
Some experience with shop lathes.
Experience with spray painting equipment (preparation and application.)
Experience with commercial type wire brushes, grinders, drills and hydraulic sheet cutters.

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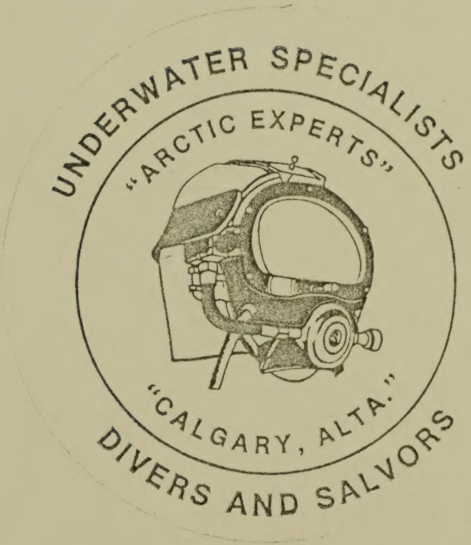
COSTS - (based on 12 hour days)

Trec	with RS7 acoustic positioning a tracking system - including 35 MM camera, hole saw, superintendent & technician. --------------------------------- Standby (bad weather) $2,150.00per day	$ 2,750.00 per day
Diving Team	2 man shallow water diving team (1 Trec assistant 1 - 35MM camera developing technician) (no standby rate)	$ 650.00 per day
ARCHAEOLOGIST	(no standby rate) -------------------	250.00 per day
SHIP RENTAL	-- - standby (bad weather) $2,000.00 per day.	$ 2,900.00 per day
	TOTAL -----------	$ 6,550.00 per day

Estimated time - 30 days on site - $6,550.00 x 30 = $196, 500.00.

Archaeologist	4 week preliminary research - 8 weeks follow-up research & report preparation maximum - 12 weeks x $750.00 per week	$ 9,000.00
Placing Mooring Anchors		$ 9,100.00
Estimated Total	---------------------------------	$214,600.00

EXPENSES - cost + 22%	Estimated cost
Trec - Video tapes - 100 tapes x $40.00 -------------	$ 4,000.00
35 MM film - 2000 shots ----------------------	$ 500.00
Developing chemicals -------------------------	$ 500.00
Printing (2,000 slides) ----------------------	$ 1,500.00
Customs entry fee (if not exempt) ------------	$ 2.500.00
Mobilize & de-mobilize equipment - Morgan City to Hamilton ------------------------------------	$ 6,000.00
Mobilize & de-mobilize on ship ---------------	$ 4,000.00
Personnel - travel & meals--------------------	$ 1,000.00
	$20,000.00
Archaeologist - cost + 22%	
On site consultants (if required))Conservation & ship construction)	
Maximum of 8 days x $200.00 per day ----------	$ 2,000.00
Expenses for consultant (if required) est. ---	$ 2,000.00
Photographic and art work est. ---	$ 1,000.00
Report production - 1 orginal & 5 xerox copies ------------------	$ 500.00
Expenses during reasearch periods max. --- (Transportation & accommodation, etc.)	$ 1,200.00
	$ 6,700.00
Diving Team - cost + 22%	
Travel & meals --------------------------------	$ 1,000.00
Project supervisors travel & meals -----------	$ 500.00
Equipment freight ----------------------------	$ 200.00
	$ 1,700.00
Meals cost + 22% - $150.00 x 30 days ----------------	$ 4,500.00
Estimated total expenses----------------------------	$32,900.00
ESTIMATED TOTAL COSTS - Trec, Diving Team,Archeeoligist - ship -------------------------	$214,600.00
- Expenses -------------------	32,900.00
	$247,500.00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